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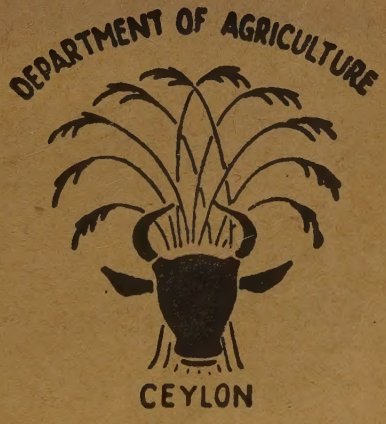

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TROPICAL AGRICULTURIST

AGRICULTURAL JOURNAL OF CEYLON

VOLUME CXIV, NUMBER 4, 1958

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CEYLON DEPARTMENT OF AGRICULTURE

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EDITORIAL

The Relation of Rice Blast to Fertilizer Use

RESEARCH achievements and extension efforts of the Department of Agriculture have not only raised Ceylon's rice yields to unprecedented levels, but have transformed the peasant's techniques of rice growing. Probably the most significant change relates to the use of fertilizers. In the traditional pattern of rice culture, fertilizers had no place. As recently as 1937, the quantity of artificials applied on Ceylon's rice crop does not appear to have exceeded 120 tons. In 1958, the application of fertilizers rose to 18,000 tons, and the fertilized area expanded to 391,000 acres, representing over 37 per cent. of the island's cultivated rice acreage.

For many years, rice blast, caused by the fungus *Piricularia oryzae* Cav, had been a localized and inconspicuous disease. With the phenomenal spread in fertilizer use, blast has assumed the magnitude of a major hazard. If the present trend in fertilizer use continues, this disease is likely to become the most serious limiting factor to raising rice yields.

That the excessive use of nitrogen fertilizers promotes *Piricularia* attack is common knowledge. The aggravation of *Piricularia* damage by nitrogen fertilization is particularly pronounced in the *indica* forms indigenous to the tropics. *Indica* varieties, especially the types that exhibit low fertilizer response, possess, at least in the early stages of growth, a strikingly higher rate of nitrogen uptake than the *Japonica* forms grown in temperate latitudes. Nevertheless, recent studies by Dr. K. Sakai, Colombo-Plan Geneticist from Japan, have failed to reveal a clear correlation between blast resistance and fertilizer response within the *indica* group. The Indonesian selection *Mas* is a case in point : this strain manifests marked fertilizer response but is extremely susceptible to blast.

Although the physiological behaviour of *indica* varieties appears to predispose them to blast, numerous strains within this group possess an effective mechanism for resisting invasion by the blast fungus: resistant strains manifest ' hypersensitivity ', and the invading fungus is sealed off by a barrier of dead cells. The Japanese have used *indicas* that possess this mechanism extensively in programmes of breeding for blast resistance.

The use of resistant varieties provides, of course, a more attractive means of blast control than fungicidal measures. In Ceylon, however, marked progress in breeding for blast resistance was not possible, till Dr. H. Okamoto, Colombo-Plan Pathologist from Japan, introduced in 1958, techniques of producing epiphytotics of Piricularia. Dense planting, heavy nitrogen applications and the use of upland nurseries are the chief features of these techniques. The low availability of silica in upland nurseries and the consequent low silica intake by seedlings lead to heavy blast infestation in the field: a silicified epidermis offers mechanical resistance to penetration by the blast fungus, and constitutes the plant's first line of defence. It is only in inundated soils that adequate quantities of silica go into solution and become available to rice seedlings. Apart from the part it plays in determining resistance to blast, silica has important functions in the physiology of the rice plant, probably the most important of which is its stimulant action on the process of nitrogen assimilation. In rice, silica yields in importance only N, P and K, and should certainly be considered the fourth major element.

Results of tests for blast resistance conducted by the Department's Pathologists on a wide range of rice varieties are reported herein. The number of selections that manifest marked resistance is encouraging. Particularly noteworthy in this respect are the high-fertilizer-response hybrids recently issued by the Central Rice Breeding Station, Batalagoda. In the breeding programmes now in progress at Batalagoda and Karapincha, the resistant parents are mainly Indian and Formosan. One Coimbatore parent reputed to be highly resistant throughout India has, however, succumbed to physiologic races of *Piricularia* in Ceylon. Physiologic specialisation may bulk large in future programmes of breeding for blast resistance.

SIR THOMAS DALLING

THE 'Tropical Agriculturist' has the privilege of publishing through the courtesy of FAO, a series of twelve articles by the eminent Veterinarian, Sir Thomas Dalling. The first of these articles deals with the " Role of Veterinarians in the World Economy " and is reproduced in this number.

Sir Thomas Dalling was born in a village near Edinburgh in 1892 and with the aid of a Carnegie Scholarship, studied at the Royal (Dick) Veterinary College, Edinburgh, where he won 15 silver medals, the Fitzwygram Prize as the best student in all five veterinary colleges in the United Kingdom and the Williams memorial medal and prize as the best student in the final year.

From this brilliant start he never looked back and in the course of his long, outstanding career has made important contributions to almost all branches of veterinary science. He distinguished himself during the 1914-18 war, when he was put in charge of the veterinary laboratories in France and introduced the use of " Reading Bacillus " in the treatment of wounded horses. After the war, he was appointed Assistant Professor to the Department of Pathology at the Glasgow

Veterinary College where he not only taught but conducted research into such problems as braxy in sheep, and lamb dysentery.

Four years later he joined the Wellcome Physiological Research Laboratories where he worked for 14 years and played a major part in evolving sera, anti-toxins and other therapeutic products.

In 1937, at the early age of 44, he was elected to the Professorship of Animal Pathology at Cambridge University. In this capacity, he also acted as Director of the Institute of Animal Pathology where he initiated and supervised much valuable research in tuberculosis and the use of tuberculin, foul paralysis and infertility in cattle.

Five years later, he was appointed Director of the Ministry of Agriculture's Veterinary Laboratory at Weybridge and was influential there in research and practical work which led to the introduction of Strain 19 vaccine, PPD tuberculin, the rapid test for pullorum disease and crystal violet swine fever vaccine.

He was appointed Chief Veterinary Officer of Great Britain in 1949, for some time holding that appointment in conjunction with being Director of the Weybridge Laboratory. When he retired at the age of 60, he joined the Food and Agriculture Organization as Senior Veterinarian in charge of veterinary activities. In the five years he served FAO, he travelled to all parts of the world and has made outstanding contributions to the control of many of the world's animal diseases. Sir Thomas has, in fact, played a remarkable part in the establishment of international methods of control of disease as, for instance, in the program he developed for control and eventual eradication of rinderpest. He is the architect of the European Commission for the Control of Foot-and-Mouth Disease and has for many years been intimately associated with the Office Internationale des Epizooties.

Having passed the retiring age for FAO officers, Sir Thomas has left the staff but is in constant demand as a consultant. As such he continues his work for FAO in many countries of the world.

Sir Thomas is a fellow of the Royal College of Veterinary Surgeons, M.A. (Cantab.), LL.D (Glasgow), D.Sc. (Belfast), D.Sc. (Bristol), D.V.M. (Hanover) and F.R.S.E. He is an honorary member of a number of Divisions of the British Veterinary Association and of innumerable veterinary asscociations abroad. He has been awarded the Victory Medal by the Central Veterinary Society, the Dalrymple-Champneys Medal, the Sir Thomas Baxter Medal and the John Henry Steele Medal.

He was knighted in 1951 in recognition of his meritorious public and professional services.

THE ROLE OF THE VETERINARIAN IN WORLD ECONOMY

By Sir THOMAS DALLING

VETERINARIANS are individuals who have undergone special training and have received appropriate education to fit them to undertake the many duties which fall upon the veterinary profession throughout the world. These duties vary, but are essentially concerned with the health of the animals.

Agriculture occupies an important place in most countries and the maintenance of livestock of different kinds is an essential part in developing any agricultural policy. The wealth of a country is often judged by the numbers and quality of its livestock and in some countries the livestock industry is already in an advanced state: in others, hithero less developed, more attention is now being given to improvements whereby the demands of human population for proteins of animal origin, at present in short supply, can be met from within a country as well as with expectations that exports of livestock and for livestock products may be possible.

Veterinarians have essential duties with livestock everywhere. For the best results from livestock, it is necessary to give attention to three points :—(*a*) the type of animals for the purpose for which they are required ; (*b*) the nutrition of the animals suitable and necessary for that purpose ; (*c*) the health of the animals to ensure that maximum results may be obtained.

It appears often to have been considered, possibly more in well developed countries, that veterinarians are concerned with, and their services used almost exclusively for, the treatment of animals suffering from some disease or injury. This may have been largely true in past years, but it no longer holds good for, generally speaking, the aim is now to prevent rather than cure disease. Valuable individual animals will certainly continue to have much veterinary attention and rightly so, but the trend today is to deal with the herd or group of animals rather than with the individual. This holds good in all parts of the world although, even in less developed countries,

circumstances arise when the individual animal must receive attention, as, for example, valuable imported breeding stock. Although this trend may be looked upon as somewhat of a new development, many examples can be given of mass treatment of livestock in the control of epizootics carried out by vterinarians.

Veterinarians are, primarily, the custodians and guardians of the health of animals. Their important duty is, therefore, concerned with the prevention of disease, which is any departure from health, taking any action, when considered necessary, to restore health and to maintain and improve health to meet the requirements demanded from the animals. Bearing in mind that animals are kept for specific purposes and that health plays an important part in meeting the demands, veterinarians must concern themselves to some extent also with breeding, nutrition and general management or husbandry of livestock. It is not intended to convey the impression that veterinarians should be responsible for these general subjects: from their training and experience, however, veterinarians are best suited to give attention to the aspects of these subjects which have any bearing on the health of animals. In animal breeding, by artificial insemination, which is now being encouraged throughout the world, the possibility of conveyance of venereal diseases comes within the province of the veterinarian as do the effects on health following the feeding of introduced plants and crops.

Diseases of a highly infectious nature, with the prevention and control of epizootics or enzootics, must always be in the minds of veterinarians in every part of the world: without the practice of control measures the resulting damage can be great, with consequent loss not only to individuals but also to the country's economy. In countries which export livestock and products of animal origin, the losses can be felt over a long period, because importing countries often prohibit the entry of any livestock or their products from countries or areas in which certain animal diseases exist or demand certain conditions which are expensive to fulfil. Modern methods of diagnosis and preventive treatment are gradually reducing the prevalence of many of the recognized infectious animal diseases : the eradication of some of them from some parts of the world is now in sight.

While veterinarians accept responsibility for the care of the health of animals from the point of view of livestock economy, they have also an added responsibility because some of the diseases affecting animals are transmissible to human beings. The group of such

diseases, termed zoonoses, is quite large: much credit and appreciation must be given to the medical authorities for their excellent work in the treatment of human beings suffering from such diseases, for their efforts are leading to good results. On the other hand, it must be pointed out that the reservoirs of these infections are animals and, until they are eradicated from animals, the risk of the infection being conveyed to human beings will remain through contact or the consumption of infected animal products. The economy of a country or area can be influenced to a considerable extent by the loss in man-hours due to such infections. Veterinarians, therefore, have a considerable responsibility in connection with the prevention of human diseases and suffering and have to be considered as " guardians of human health " in some of its apects.

Again, we have to consider the work of the veterinarians in ensuring that meat and meat products are supplied to the consuming public in a safe and wholesome state. In most countries where large abattoirs are used, veterinarians are responsible for ensuring that all meat and meat products leave the premises in a satisfactory condition for human consumption. This entails the inspection of animals before slaughter, the examination of meat and offal, the condemning of parts considered to be unfit in any way for human consumption, and giving the necessary attention to the cleanliness and hygienic conditions under which all the operations in the abattoir are carried out.

In some countries, the duties of veterinarians extend even further and they are responsible for the satisfactory condition in which fish and sometimes all edible products are made available to the public. In such cases, their responsibility does not end until the food-stuffs are displayed for sale in the retail shops and markets.

In countries which export meat and products of animal origin, including such items as hides and skins, wool, hair, bones, etc., veterinary certification of their freedom from certain infectious conditions is required by importing countries.

We have discussed livestock and their products: we must not forget, however, the smaller animals and poultry. Dogs and cats are highly prized in some countries, the former not only for the work it does for man but, together with the cat, for its companionship which adds to the happiness and contentment of the owners. In many towns throughout the world, veterinarians are busily employed in problems of health and disease of these animals and note must also be made

that dogs and cats are also susceptible to some diseases communicable to human beings, for the recognition of which veterinarians must always be on the alert.

These are some of the main duties of veterinarians, all of which have some bearing on world ecnomy. Other duties are carried out largely by veterinary services as opposed to practising veterinarians, but sufficient has been said to show the important place occupied by veterinarians in the world today.

No matter how efficient an individual veterinarian or a veterinary service may be in the work allotted to them, they depend on the results of research work for their knowledge of new methods of dealing with problems of animal and human health. It has been truly said that a profession is "dead" without research activities. For many years, veterinary research was starved by the lack of funds and it was left to the keenness of a few, often supported by private enterprise to engage in the subject. Notwithstanding the many difficulties, these workers made valuable contributions to the general knowledge of the causes, prevention and treatment of animal diseases. In recent years, however, much more financial support from public funds and some further contributions from private enterprise have become available. This has resulted in assuring young men and women a future career in veterinary and other resarch work: thus, research has attracted more and more personnel and the field is now being covered to a marked degree. More and more research work is being undertaken and problems are gradually being solved. Veterinary activities are also profiting by the results of research work in other branches of science, sometimes far removed from animal diseases, for any discovery which may have a bearing on their work is largely applied by veterinarians. Team work between veterinarians and other scientifically trained personnel is now the "order of the day" and is providing solutions to many problems. Here again, then, is a veterinary activity of importance to world economy.

In order that veterinarians may undergo the necessary training and gain experience in the many subjects with which they must be familiar, their education is carried out in veterinary schools or colleges, which are usually part of a University. Every student who enters a veterinary school after attaining matriculation standard in general education is required to pursue a course of study in the subjects of basic science in order that he may appreciate and understand the more applied subjects peculiar to veterinary science and medicine. For the teaching of these subjects, the veterinary student

often attends classes along with others reading for degrees in sciences other than veterinary. The more purely veterinary subjects are taught by veterinarians experienced in teaching and the teaching field is now claiming more and more young men and women with the necessary outlook and aptitude. These individuals are doing important work in preparing veterinary undergraduates for their future careers throughout the world.

Very often these teachers also engage in refresher courses, held periodically and attended by graduate veterinarians, the object of which is to give information on the latest discoveries, the application of which will ensure more rapid and surer results in dealing with animal diseases.

Veterinarians also are employed in laboratories which are largely devoted to the diagnosis of disease and the solutions of problems which present difficulties to veterinarians in the field.

It will be understood that the number of vterinarians may not be in proportion to the number of animals in a country or area, the stage of development of a country and the economic aspects of the livestock industry being closely related to their numbers. It is of much interest, however, to observe that practically all countries throughout the world appreciate now more fully the value and importance of veterinary services: this is reflected in increases in veterinary personnel in many countries and the establishment of veterinary services, even sometimes on a modest scale as a beginning in countries which are now becoming independent.

It can also be appreciated that all the details of the veterinary activities as described in this article cannot always be carried out by veterinarians, especially in countries in which the livestock population is scattered over large areas and in which the economy cannot support large numbers of graduates of the veterinary profession. Much useful work is being done by laymen, trained for specific duties and working under the supervision of veterinarians. Such personnel have a useful place in the veterinary activities in some countries.

Attention must be drawn to the assistance rendered by international bodies interested in veterinary work. In the further development of some countries, the role played by agriculture has not been omitted and attention is being given by those bodies to the livestock industry. Realising that animal health is one of the important considerations in assisting the less developed countries in their economy, and the need for producing more and more supplies

of protein of animal origin throughout the world, these international organisations collaborate with the Governments of such countries by employing veterinarians to visit and often reside in the countries for periods, advising on and participating in the control of animal health and disease. Much valuable work has already been done and these activities will be continued as long as the necessary finances are made available.

In this general article, an attempt has been made to show the scope of veterinary work in the different fields and how the veterinary profession today is playing an important role in world economy. It is hoped to follow up this article with further articles in which more attention will be given to details of some of these activities, including disease control and the work in progress by veterinary services and international organizations.

THE TRISTEZA DISEASE OF CITRUS IN CEYLON

J. W. L. Peiris and A. L. Bertus
(*Department of Agriculture, Ceylon*)

It has been a general observation in many countries that sweet orange scions when budded on sour orange root-stocks decline in growth very rapidly. Originally this phenomenon was thought to be due to stock-scion incompatibility, but later, through the work of Fawcett and Wallace (1 & 2), this decline was demonstrated to be due to a virus. The virus may have been already present in the scion if it had been taken from an infected tree, or the clean bud graft may become naturally infected by vectors notably *Toxoptera citricidus* (Kirk) which was shown by Meneghini (3) to be a vector of the virus. The virus caused a necrosis of phloem just below the bud union preventing the translocation of starch to the roots, and the trees showed symptoms of decline. The test for starch in the tissues above and below the bud unions confirmed this view. Symptoms normally observed in declining trees are chlorosis, stunting, dropping of leaves and die-back. These symptoms are not unlike those caused by drought, root rot, eel worm, lack of cultivation, manuring &c.

The virus which is called Tristeza has been recorded from North (1) and South America (3), Africa (5) (6), Hawaii (7), Australia, New Zealand (8 & 9) and more recently from Israel (10). It is reported to have destroyed upwards of 7,000,000 trees in Brazil alone and nearly 400,000 in California.

Diseases of citrus in Ceylon came into prominence about the year 1956 in the Wellassa (Bibile) area where considerable cultivation of citrus existed. Reports, at this time, of die-back and chlorosis etc. revealed the presence of the common citrus fungus diseases such as pink disease (*Corticium salmonicolor*) and mildew (*Oidium tingitaninum*), and control measures for these were recommended. It was also observed that in many areas, citrus had been planted in unsuitable and shallow soil, and no proper systems of manuring, cultivation and soil conservation were carried out. Latterly it became apparent that even after the control of mildew and pink diseases even young citrus seedlings tended to become chlorotic and unthrifty.

Moreover the decline problem of seedling citrus was found not to be only confined to the Wellassa (Bibile) area but was also observed in other parts of the island.

Richards (11), (12) in his studies on the influence of the rootstock of budgrafted citrus found that Marsh's seedless grapefruit made poor growth when budded on sour orange. Similarly, local varieties of sweet orange such as Bibile and Vavuniya made unhealthy growth on sour orange stock. Chlorotic symptoms in plants of these stock-scion combinations are delayed where soil and climatic conditions are favourable for healthy growth of citrus. On grafted citrus, the density of starch as revealed by the iodine test was considered a test of the activity of the tristeza virus. Affected trees gave a higher concentration of starch in tissues above the bud-union, but little or no starch below it owing to necrosis of phloem just below the bud union. Richards concluded that the distribution of starch in these bud grafts was normal in spite of their chlorotic and stunted appearance, and regarded that the results were not conclusive enough to prove that the failure of these grafts on sour orange was due to a virus.

Up to the present, available literature has shown that tristeza is mainly a malady affecting bud grafts and seedlings of lime. In other countries the ameliorative measures recommended were the budding of sweet orange on sweet orange or other tolerant stocks, or the growing of seedlings. It soon became apparent that inasmuch as over 95 per cent. of the citrus in the Bibile area were orange seedlings which were showing signs of declining, our problem was slightly different from that in other countries. Experiments were directed to explore the possibility of the association of a virus with the decline problem of citrus in Ceylon.

GRAFTING EXPERIMENTS

The first tests to investigate the virus nature of declining citrus were initiated in November 1955 (Peiris, 13). Six sets of bud grafts were made using scions from five-year-old, declining Bibile sweet orange trees and from apparently healthy Bibile sweet orange trees. In all cases, the grafts were made on plants growing in the field, the age of stock plants varying from 7 to 8 months. Ten bud grafts were made for each set as follows :—

At Bibile Agricultural Station

Set 1. Scions from apparently healthy Bibile sweet orange budded on rough lemon.

Set 2. Scions from declining Bibile sweet orange budded on rough lemon.

At Peradeniya Horticultural Division Nursery

Set 3. Scions from apparently healthy Bibile sweet orange budded on rough lemon.

Set 4. Scions from declining Bibile sweet orange budded on rough lemon.

Set 5. Scions from apparently healthy Bibile sweet orange budded on sweet orange.

Set 6. Scions from declining Bibile sweet orange budded on sweet orange.

The indications at the end of six months were as follows :—

At Peradeniya, scions from declining trees when budded on sweet orange stock showed dwarfing of scion growth and a bronzed yellow colour of leaves which became chlorotic in time. Scion growth was markedly stunted (Fig. 1). The healthy scions showed quite normal growth and a green healthy flush and the size of the new growth produced was three or four times that of the scions from declining trees. On rough lemon, both diseased and healthy sweet orange scions showed a general healthy appearance. The scions from healthy plants however showed a slightly better growth than buds taken from diseased plants.

In the Bibile experiment, buds both from declining and healthy plants showed quite vigorous growth on rough lemon stock and no differences were observed between them.

Tests for starch distribution in the two sets of grafts made with diseased and healthy scions on sweet orange stock at Peradeniya showed a depletion of starch below the bud union in the former. Moreover, on these grafts there were obvious signs of phleom necrosis below the bud union inhibiting the translocation of starch to the roots. In the sets of grafts made with scions from apparently healthy trees, as well as all grafts made on rough lemon the starch distribution was normal and no signs of phleom necrosis were visible at the end of seven months. Rough lemon stocks are more tolerant of the virus and decline on this stock is known to be much delayed.

The symptoms presented by grafts from scions of the declining trees as compared with those from healthy orange trees on sweet orange stocks are reminiscent of the behaviour or tristeza-infected in comparison with healthy orange scions on sour orange (Fawcett &

Wallace, 1). Although, so far, no definite reports of the decline of sweet orange on sweet orange stocks are available, these tests strongly indicated the action of a virus of the tristeza type as being associated with the decline of the citrus grafts under consideration.

Kiely (14) in his report on the decline problem of citrus in the lower Uva valley and other areas in Ceylon strongly supported the possibility of the association of a virus in the decline of the bud grafts made with scions from declining trees referred to in the tests mentioned above. Notwithstanding the fact that decline of orange seedling plants on their own roots or for that matter even bud grafts of sweet orange on sweet orange has hardly been reported as due to the tristeza virus, he argued that if the Bibile seedless orange can decline so rapidly on its own roots it is reasonable to expect that naturally infected Bibile seedlings grown under orchard conditions where the virus and vector may occur can be expected to decline as well. Kiely further demonstrated the presence of vein flecking, chlorosis, stem pitting and die-back symptoms of lime seedlings growing under orchard conditions in the areas where decline of orange was observed. Although tristeza-affected orange shows no symptoms by which its presence could be definitely identifid, lime on the other hand constitutes an indicator plant which reacts to infection by tristeza with the definite symptoms mentioned above. Although a strong case has been built up on circumstantial evidence for the existence of tristeza in Ceylon citrus, the conclusive establishment of the presence of the virus must await its actual transfer to healthy seedlings, and the following experiments were directed to that end.

TRANSMISSION EXPERIMENTS

Eight-month-old citrus seedlings of West Indian lime, Washington Navel and Bibile sweet orange were raised from seed under insect proof conditions and used for the experiment. Five plants of each variety were used for inoculation and five other plants maintained as controls.

A black citrus aphid was found at Bandarawela and Peradeniya colonising the young flush of orchard citrus trees. Specimens of this aphid were indentified by the Commonwealth Bureau as *Toxoptera citricidus* (Kirk), the most efficient vector of the tristeza disease, and transmission experiments were attempted with this aphid.

Young flush from a tree showing decline was brought to the Laboratory, and aphids collected from a citrus plant in the orchard were transferred with a camel hair brush on to the flush. At the end

of 24 hours feeding on this flush, they were carefully transferred to the test plants at the rate of 20 aphids to each plant where they quickly settled down to feed. At the end of two days the insects were destroyed with a nicotine sulphate spray, and the inoculated plants were returned to the insect proof house for incubation. The results of this experiment are as follows :—

West Indian Lime

At the end of one month the first signs of vein clearing were found in the new flush in three of the five plants inoculated. Vein clearing developed progressively until secondary and tertiary veins were completely cleared. Chlorosis was observed on the young flush. A fortnight later, chlorosis intensified, young leaves became stunted and boat shaped, and vein clearing even extended to the fourth-order veins. At the end of 100 days, one plant showed a tendency for corking of the veins. All three plants showed severe stem pitting.

Washington Navel Sweet Orange

Of the inoculated seedlings, symptoms appeared in one plant at the end of four weeks, and the first symptom was a clearing of the secondary and a few tertiary veins. The vein clearing was of a continuous type extending to almost the whole length of the secondary veins. Slight chlorosis of the affected flush was obtained at the end of ten weeks. Another feature was the water-soaked appearance of the cleared veins when the lower surface was examined in reflected light.

Bibile Sweet Orange

Two plants showed similar symptom expression in this group at four weeks. These symptoms were very similar to those on Washington Navel in the type of vein clearing, slight chlorosis and water soaked appearance in reflected light. Again all check plants grew normally.

The symptoms expressed on West Indian Lime seedlings obtained in this test are generally typical of the symptoms described by Wallace (1) and other workers for the tristeza virus. The second experiment was carried out with the same technique on a larger number of varieties of lime and sweet orange seedlings. The number of infective aphids per test plant was increased to 35. The results of the experiment are summarised in Table 1.

Table 1. Transmission of Tristeza Virus to Orange and Lime Seedlings

Variety	*Number of Plants*	*Appearance of First Symptoms*	*Number Infected*	*Incubation Period*	*Number Infected after 40 Days*	*Vein Clearing*	*Stunting and Curling of Leaves*	*Chlorosis*
West Indian Lime	5	23.11.57	2	23 days	5	Clearing of 3rd and 4th order veins very prominent	Young leaves stunted and curved in 3 plants	Marked chlorosis in 3, slight chlorosis in 2
Thimburane Lime	5	23.11.57	2	23 days	5	Clearing of 3rd and 4th order veins very prominent	Young leaves stunted and curved in 4 plants	Marked chlorosis in 2, slight chlorosis in 3
Mindora Lime	5	23.11.57	4	23 days	5	Clearing of 3rd and 4th order veins very prominent	Young leaves stunted and curved in 4 plants	Marked chlorosis in 1, slight chlorosis in 4
British Guiana Lime	5	23.11.57	4	23 days	5	Clearing of 3rd and 4th order veins very prominent	Young leaves stunted and curved in 4 plants	Marked chlorosis in 2 slight chlorosis in 2,
Caipira Orange	7	25.11.57	2	25 days	7	Clearing of 2nd and 3rd order veins in 4 Vein flecking in 3	Young leaves slightly curved	Slight chlorosis in 6
Omantai Orange	5	27.11.57	1	27 days	3	Clearing of 2nd order veins	Nil	Nil
Valencia Orange	5	22.11.57	1	22 days	2	Vein clearing of 3rd and 2nd order veins	Nil	Slight chlorosis in 1
Bibile Orange	5	22.11.57	1	22 days	3	Clearing of 2nd and 3rd order veins	Young leaves slightly curved in 1	Slight chlorosis in 2
Washington Navel Orange	5	1.12.57	1	30 days	3	Clearing of 2nd and 3rd order veins	Young leaves slightly covered in 1	Slightly chlorosis in 2

In this experiment, careful observations were made to detect the first symptoms of vein clearing. It will be seen that the period of incubation on limes was as short as 23 days. On orange, the incubation period varied from 22 to 30 days.

The symptoms obtained in lime and orange seedlings followed the pattern shown by the inoculated plants in the first experiments. The lime seedlings of the four varieties used responded very similarly and 100 per cent. infection was obtained. Vein clearing of the continuous type extending to secondary, tertiary and lower order veins was produced and was accompanied by marked chlorosis, dwarfing of leaves and curving of the leaf blade resulting in a boat shaped appearance. At this stage there was no marked difference in the reaction of the different lime varieties to this disease. Three months after inoculation cork formation along the veins of the leaves was observed in all inoculated plants (Fig. 2). On decortication the stems showed fairly severe stem pitting (Fig. 3).

The orange varieties also closely followed the symptom pattern described in the earlier experiment. All the varieties gave characteristic vein clearing and slight chlorosis of the leaves. Slight stem pitting was also observed on the plants showing leaf symptoms three months after inoculation.

DISCUSSION

Tristeza virus is known through the work of several workers to show vein clearing on lime. The type of clearing described and illustrated is more of a vein-flecking type where parts of veins only are cleared rather than the continuous clearing of veins of second, third and even lower order obtained with the virus under consideration. Wallace (1) states that "it is necessary to distinguish between the symptoms of psorosis virus and tristeza because psorosis may be present either alone or in combination with tristeza. The vein clearing due to psorosis is much more distinct and is more limited to the veins. The symptoms are persistent and are often present on the old leaves. On the other hand psorosis may cause blotchy patterns, less clearing of leaves but broader steaks which ordinarily disappear as the leaves mature. In case there is difficulty in diagonosis of the basis of leaf symptoms the lime seedlings should be examined for stem pitting. In Californian, Mexican and West Indian Lime seedlings no virus other than the tristeza has induced stem pitting." Stem pitting was observed in the inoculated West Indian Lime seedlings used in the experiment. Further the only other virus that is capable of producing vein clearing on orange is psorosis, but the type of vein

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clearing observed differs from what is described for psorosis and psorosis is not known to be transmitted by a vector. These findings indicate without doubt, the presence of a virus of the trisetzt type.

The continuous type of vein clearing observed in the lime and the characteristic vein clearing in orange are features not normally reported as symptoms of the tristeza virus. Moreover in orchard trees at Peradeniya showing decline symptoms, vein clearing and the water soaked appearance of cleared veins has now been observed. However, Grant (16) has noted some vein clearing on sweet orange together with retardation of growth, chlorosis and yellowing of leaves which he attributes to an initial shock effect followed by some recovery and new growth. The conditions observed on the sweet orange seedlings that have been described probably admits of a similar explanation. Subsequent observation has shown that after the initial shock symptom of vein clearing this symptom tends to be gradually suppressed and only appears in occasional flushes. Adult grafted trees carrying the virus have now been observed to exhibit occasional streaks of vein clearing in some flushes in addition to the symptoms of yellowing, chlorosis &s. Seedling orange trees on the other hand, have been observed to decline quite considerably under Ceylon conditions, whereas in other countries the effect of tristeza on seedling orange is not known to be of much importance, and moreover budding sweet orange on sweet orange stocks is reported to give considerable tolerance to the virus. In Ceylon sweet orange on sweet orange bud-grafted plants have been known to succumb to the virus. The virus recorded in Ceylon may therefore appear to be a more virulent strain of the tristeza virus than those described hitherto.

SUMMARY

1. A decline of sweet orange scions on sweet orange has been observed in Ceylon as well as a decline of sweet orange seedlings on their own roots.
2. Grafting experiments have shown that scions from declining sweet orange when budded to healthy stocks give grafts that decline in a short time.
3. The black citrus aphid *Toxoptera citricidus* was effective in transmitting the virus to orange seedlings and lime seedlings.
4. The virus is capable of causing a characteristic continuous vein clearing on various varieties of orange seedlings rather different from what has hitherto been described.
5. Owing to this feature and its ability to cause decline of sweet orange seedlings on their own roots, this virus would appear to be a virulent strain of the Tristeza complex.

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METHODS OF DIAGNOSING "AKIOCHI", IRON AND HYDROGEN SULPHIDE TOXICITY IN THE WET-ZONE RICE FIELDS OF CEYLON

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1.—DIAGNOSIS OF IRON TOXICITY IN PADDY FIELDS

Comparable physiological diseases of rice occur in various countries in Asia. These include "akagare" of Japan, "mentek" of Java, "penyakit mereh" of Malaya and "bronzing" of Ceylon. In these diseases the leaves of the affected plants turn reddish-brown.

"Akagare" disease in Japan is characterized by reddish-brown spots at the tip of lower leaves. The discoloration spreads over the entire leaf and causes ultimate dying-off. It resembles potassium deficiency in its symptoms as well as in its positive response to potassium application (Baba, 1954).

On sandy soils or peaty ones along the western coast of Ceylon, diseases of the same type are found, but in Ceylon, diseases of other types called "bronzing" or "browning" occur in which the whole leaf gets discoloured reddish-brown or dark-brown, starting from the leaf tip; potassium fertilization has no appreciable effect on this type of disorder (Kandiah, 1952). The writer also observed in Ceylon the occurrence of physiological diseases resembling potassium deficiency and it was, according to the writer's observation, "bronzing" that occurred most extensively.

Ponnamperuma, Bradfield & Peech (1955) found an intimate relationship between the occurrence of "bronzing" and the ferrous concentration in the soil percolate, and they postulated that the reduced products in the soil, especially ferrous iron, were the causative agents of the disease.

The writer agrees that "bronzing" is related to the absorption of ferrous iron in excess, judging from (*a*) the marked color reaction

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at the base of the shoot of an affected rice plant when it is treated with ortho-phenenthroline, an indicator of ferrous iron, and (*b*) the existence of a close correlation between the severity of the incidence of bronzing and the degree of reddish-brown coloration of the roots due to oxidized iron adherent to its surface.

Excessive ferrous iron in the soil may have a toxic effect on the functions of the root even when "bronzing" is not recognized. "Bronzing" is a typical expression of the existence of excessive ferrous iron in the soil, and may be considered an indicator of iron toxicity. The writer describes below some methods of recognizing iron toxicity.

1. Diagnosis by Soil Properties

Iron toxicity is liable to occur on those low and wet fields which are adjacent to the highlands of tea or rubber estates, soil of which is ferruginous acidic laterite. Such fields are usually irrigated by streams originating from highland springs, or by the drainage water from such highlands. Springs from underground streams, originating from highland drainage water, often occur within paddy fields.

Irrigation water under the above conditions is acidic and has a pH ranging from 5.0 to 5.8. In contrast to this, the usual irrigation water has a pH of 6.0 to 7.0.

The pH of irrigation water can be roughly determined by the following colorimetric method :

Pour a small amount of the irrigation water to be tested into a porcelain dish and add two or three droplets of the universal indicator. The water will develop one of the following colours according to its pH value :

pH 4, red-orange ; 5, orange ; 5.5 orange-yellow ;

It is better to prepare by the use of a pH meter, a series of colour standards showing rough values of pH.

Various types of soils are badly affected by iron toxicity, viz. sandy, sandy loam, loam clay, and peaty soils ; of these sandy and sandy loam soils are most common.

The affected soils contain organic matter (humus) to some extent and have the property to be rapidly reduced when irrigated.

On the soil surface of the irrigation channels and the field, there develops a thin film of oxidized iron of red, rusty colour.

Euglenas occurring at the surface of the water should not be mistaken for a film of oxidized iron, as the former produce a thin red film under direct sunlight. This film of Euglenas can easily be distinguished from oxidized iron as, according to Mr. I. Gunawardena's observation, it changes into green when the sunlight becomes dim, or the sky becomes cloudy.

2. Diagnosis by Crop Characteristics

The past occurrence and severity of " bronzing " should be first investigated. In investigating them, cases in which non-resistant varieties (e.g. Murugakayan 302) were cultured should be examined, as many of the native local varieties are resistant to " bronzing ".

Usually, " bronzing " occurs on two occasions. The first one, at the maximum tillering stage, i.e. 5 to 7 weeks after sowing or transplanting, and the second one, at the booting or heading stage. The occurrence may be only once, according to the soil, climate or the year.

A survey must be carried out at these most susceptible stages, as in most cases the disease is not so severe at other stages.

By examination it can be found out that the roots of rice plants grown on fields subject to iron toxicity are coarse and are dark reddish-brown or dark-brown in colour.

The roots are short with only a few rootlets. Black roots are not found, showing that hydrogen sulphide is not produced in the soil due to the abundance of iron. On rare occasions, however, black roots may be found intermingled with the other roots after the booting stage. It is recommended that such roots be compared with the roots of rice plants grown on nearby healthy fields. The roots of a healthy plant are yellowish-brown or light reddish-brown. Fields which have undergone a drought should not be sampled, as rice roots on such fields become healthier and lighter in colour.

(3) Immediately after pulling out a test plant, cut its base longitudinally and place two or three droplets of 0.2 per cent. orthophenanthroline solution on the cut surface with a filler or immerse the cut surface into the solution. A red coloration, of an intensity which is proportionate to the Fe" ion concentration in the base of the leaf sheath will develop.

As the colour becomes clearer with the lapse of time, over a period of half to one-half hour, the Fe" reaction at the basal end (2 to 3 ins.) may be estimated by the intensity of red coloration. For purposes of comparison, the roots of a plant grown on a field devoid of iron toxicity

naturally or by drainage should be examined simultaneously with the test roots. As the red coloration caused by ortho-phenanthroline does not fade, comparison can be made even with preserved material.

II.—DIAGNOSIS OF "AKIOCHI" AND HYDROGEN-SULPHIDE-TOXCITY

In Japan, about 600,000 hectares, which is 20 per cent. of the total rice area, are badly affected by a physiological disease called "akiochi". "Akiochi" is caused by the deficiency of nutrients such as silica, potassium, manganese and magnesium, and by injury caused to the roots by hydrogen sulphide (Baba & Harada, 1954). In Japan, such nutrient deficiency is commonly found in combination with root-injury due to hydrogen sulphide.

In Ceylon, the area of "akiochi" fields is not so large at present, but the writer fears that the area will expand with the increase in the amount of fertilizers used. Though further investigation will be needed to elucidate the cause of "akiochi" in Ceylon, in most cases "akiochi" is accompanied by the root-rot due to hydrogen sulphide. A field subject to hydrogen-sulphide-toxicity may accordingly be considered identical with one subject to "akiochi".

In Japan, there are two types of paddy soils in respect to "akiochi", viz. sandy soils (in most cases, well-drained) and boggy soils (ill-drained). In the former type of soil, root injury is mainly caused by hydrogen sulphide, while in the latter type of soil, root injury is believed to be caused by hydrogen sulphide, as well as by carbon dioxide and toxic organic acids such as acetic and butyric acids (Baba & Harada, 1954). In Ceylon too, "akiochi" is seen in sandy soils and boggy soils.

There are two methods of diagnosing "akiochi" and hydrogen-sulphide-toxicity. One is by the soil, and the other is by the crop characteristics.

1. Diagnosis by Soil Properties

(1) Soil

In most cases, the soil is a sandy or sandy loam, poor in iron.

In some cases the soil is ill-drained, particularly when mucky or boggy, containing too much organic matter (humus).

(2) Generation of hydrogen sulphide

On sandy soils, the odour of hydrogen sulphide can be detected. Transfer some surface soil from an irrigated field, into an Erlenmeyer's flask as to fill half the flask. Then place a small funnel over it, and suspend a piece of blotting paper wetted with lead acetate solution deep in the flask. A black colour will slowly develop on the blotting paper. This is due to the formation of PbS P_2 S. As the blotting paper wetted with lead acetate solution does not blacken unless there is a large quantity of hydrogen sulphide produced by the soil sample, this method is not very sensitive if the production of hydrogen sulphide is small.

In the case of an ill-drained boggy soil, an oily film of iron can be observed at the surface of the field.

2. Diagnosis by Crop Characteristics

(1) Growth and morphological characteristics of the rice plant

Plants which have been affected by " akiochi " have the following growth and morphological characteristics :

(*a*) Their growth at the early stages is normal or rather vigorous, and their leaves hang down in most cases. At the later stages, retardation in growth becomes conspicuous, and non-fertile tillers increase in number. In a boggy field, they may not show satisfactory growth at the early stages.

(*b*) They have short stalks and ears. The upper internodes are also short. Panicle exertion from the leaf sheath is poor.

(*c*) The number of spikelets per ear decreases, and there is also increase in sterility.

(*d*) The grain-weight leaf and stalk-weight ratio is small.

(*e*) Generally the paddy grains lose their lustre and dark brown spots developed on them.

(*f*) The grains, both hulled and unhulled, are inferior in quality and possess a lower thousand-grain weight.

(*g*) The lower leaves of the affected plants die off at a very early stage. At harvest time, only one or two active upper leaves remain on each stalk.

(2) Root

The diagnosis of the roots should be carried out by the comparison of affected and non-affected plants. For such comparison, plants which are of the same variety and of the same time of sowing or transplanting should be chosen. Generally speaking, roots begin to rot after the

formation of ear primordia, and rotting increases in severity after booting. Sometimes the rotting of roots begins only after heading, depending on the type of the field. During both *yala* and *maha* seasons, the investigations should be conducted to determine the stage when the root-rot begins.

The roots of a healthy plant are reddish-brown in colour, due to the coating of colloidal iron hydroxide. Healthy plants are difficult to uproot, owing to their elastic roots.

On the other hand, the roots of plants affected by " akiochi " are white or black. Plants so affected can be easily uprooted as their roots are decayed. The black coloration is caused by the adherence of black colloidal iron sulphide. The existence of the black roots indicates the generation of hydrogen sulphide in the soil.

In a boggy field, the intensity of red coloration of roots is deeper in comparison to that in a sandy field, owing to the abundance of iron in the soil, but, nevertheless, black or decayed roots are produced due to the generation of hydrogen sulphide in the soil. This is because the generation of hydrogen sulphide is governed by the quantity of decomposable organic matter, iron, and sulphur, in the soil. When the quantities of decomposable organic matter and sulphur are greater in comparison to that of iron, hydrogen sulphide is produced.

On diagnosing " akiochi ", those places which have once been affected by drought should be avoided; drought-affected plants, in spite of the whiteness of the roots, have only a few black or rotted roots.

(3) Diseases

Helminthosporium leaf-spot is most likely to occur. In Japan the occurrence of this disease is taken as an index of " akiochi ", for it is almost always found whenever " akiochi " occurs. In Ceylon, other than Helminthosporium leaf-spot, diseases such as sheath blight, leaf blast, neck-rot, and stem-rot are observed to occur.

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STUDIES ON PADDY BLAST CAUSED BY PIRICULARIA ORYZAE

1. A METHOD OF TESTING VARIETAL RESISTANCE TO BLAST

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INTRODUCTION

BLAST caused by *Piricularia oryzae* Bri. & Cav. is the most serious disease of paddy in Ceylon. It is known to be aggravated by increased use of nitrogen fertilizers (1), and as high yields are ultimately associated with the increased use of fertilizers, blast disease is one of the important limiting factors to the campaign of stepping up paddy production.

The usual control methods for blast fall into three main categories :

(i) Improved cultural practice.

(ii) Use of efficient fungicidal control measures.

(iii) Use of resistant varieties.

The development of disease resistant varieties, although a long-range project, constitutes the most practical solution to the problem of blast. By using such a variety the farmer will eliminate the labour and expense of fungicidal treatments.

The method described in this paper for testing the varietal resistance of paddy to *Piricularia oryzae* has proved to be very practicable, and the relative resistance is determined within a very short time. Briefly the method consists of predisposing the paddy plants to the disease by growing them in highland nursery beds, using sufficiently close spacing to raise the humidity in the immediate vicinity of the plants in order to favour the development of the fungus. At the same time, under these conditions the physiological status of the plant is rendered more favourable for infection. It has been found that under upland conditions silicification of the epidermal cells in the leaf is retarded and under conditions of silica deficiency the plants are also more susceptible to blast (2), possibly because assimilation of nitrogen is hampered and accumulation of soluble nitrogen occurs in the leaves, making them more susceptible to the fungus (3).

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MATERIALS AND METHODS

Since heterogeneity in the nursery could induce physiological variations in the plants thus altering the relative susceptibility to blast, great care has to be taken in the preparation of the nursery beds. The following procedure was followed :—

Rectangular nursery beds were ploughed to a depth of 6″-8″, all large clods being broken up, the land raised slightly and levelled roughly. The surface soil was next sieved with a coarse sieve and the fertilizer mixture raked into it to a depth of 4″. The beds were then given a final smoothing.

From preliminary experiments at Peradeniya and Karapincha, it was found that 4″ between rows gave the optimum spacing for uniform induction of the disease. The fertilizers used and their rates of application were as follows :—

1. Compost	0·5 oz./sq. ft.
2. Ammonium Sulphate	0·10 oz./sq. ft.
3. Conc. Super Phosphate	0·10 oz./sq. ft.
4. Muriate of Potash	0·025 oz./sq. ft.

In the sandy soils at Karapincha, magnesium chloride was added at the rate of about 0.10 gm/sq. ft. A top dressing of ammonium sulphate at the rate of 0.10 oz./sq. ft. was added about 12 to 15 days after sowing in order to increase the susceptibility of the plants to blast. Parallel rows spaced 4″ apart and about 4½ feet long running at right angles to the long axis of the nursery beds were made next, and surface-sterilized, ungerminated seed of the varieties being tested were dibbled in these rows at a rate of approximately 10 seeds per inch. Each variety was represented by one such row, and one variety was separated from the other by a single row of a standard susceptible variety (bombardment row) to provide a uniform inoculum. Careful checks had to be made to ensure that the rate of sowing was uniform throughout. Once sowing was complete the rows were covered thinly with soil and the beds were mulched with straw.

INOCULATION

As a rule, natural infection occurred readily, but to achieve uniformity in its occurrence, finely chopped, diseased paddy straw and leaves were sprinkled amongst the rows about seven days after sowing. The bombardment strips and susceptible varieties were usually infected first. In order to enable the disease to spread rapidly, the beds were watered thoroughly.

Lesions first appeared in the bombardment strips 9-12 days after sowing. The onset of the disease was always slow but its severity increased rapidly. The resistant variety showed little or no damage and stood out conspicuously between the flanking bombardment strips which, like the susceptible varieties, showed a stunted and " scorched " appearance. Four main types of lesions were noticed on the varieties being tested.

1. Minute, brown, dot-like lesions in the very resistant varieties.
2. Moderate sized, diamond-shaped or slightly elongated lesions which always showed a uniform brown colour with a yellow margin. These are associated with the moderately resistant varieties.
3. Large, watery green lesions irregular in shape found in all susceptible lines.
4. Large, white, irregular-shaped lesions which are found usually in the very susceptible types.

In some varieties the number of dot-like lesions assumed enormous proportions with the result that the leaves showed a bronzed appearance and the leaf-rolling mechanism was impaired.

DISEASE ASSESSMENT

Disease assessments were made using a standard assessment scale developed by H. Okamoto for the Ministry of Agriculture & Forestry, Japan (4), in which use was made of the approximate leaf area destroyed by the fungus expressed as a percentage of the total leaf area. The morphology of the lesions was also observed on the leaves so as to determine the resistance of the varieties. The letters D, S and L were used when over 20 per cent. of the lesions noticed were (*a*) dot-like, (*b*) small, uniformly brown, and (*c*) large acute or white respectively. The suffixes added to the letter D shows the degree of spotting noticed. The suffixes were graded from 0-10, where 0 is the least and 10 is the most affected. The varieties were graded into seven groups according to the leaf area destroyed. Their relationship is given below :—

Group	*Main Type of Lesion*	*% Leaf Area attacked*	*Degree of Resistance*
RR	D	0·2 or less	Very Highly Resistant
R	D	0·3 — 1·0	Highly Resistant
MR	D + S	1·1 — 5·0	Very Resistant
M	S	6·0 — 25·0	Moderately Resistant
MS	S + L	26·0 — 55·0	Moderately Susceptible
S	L	56·0 — 80·0	Fairly Susceptible
SS	L	80 and above	Very Susceptible

Illustrating " Studies on Paddy Blast caused by Piricularia oryzae "

FIG. I : The three principle types of lesions (from left to right)—1. The large watery-green lesion (L), 2. The smaller uniformly brown lesion (S), 3. The dot-like lesion (D).

FIG. II : Close-up of an upland nursery showing a resistant variety in the middle of the illustration.

The results of the assessments are presented in Tables 1 and 2.

RESULTS

TABLE 1

Variety	Country of Origin	12.6.58			14.6.58		
		Percent Leaf Area Attacked	Lesion* Type	Grade of Resistance	Percent Leaf Area Attacked	Lesion* Type	Grade of Resistance
Adt 18	India	73	L	S	100	L	SS
Brondel Putih	India	41	L	MS	98	L	SS
Br 4	India	0·2	S	R	0·1	L	R
HMC 12	Burma	68	L	S	100	L	SS
MYAC 104	Burma	0	D 4	RR	0	D7	RR
CO 25	India	0·3	S	R	0·1	D + S	RR
Chuban	China	100	L	SS	100	L	SS
Ch. 18	China	28	L	MS	33	LS	MS
Ch. 1007	China	13	L	M	68	L	S
Ch. 1039	China	13	L	M	68	L	S
Gendah Beton	Indonesia	35	L	MS	98	L	SS
GEB 24	India	100	L	SS	100	L	SS
Heenati 310	Ceylon	25	L	MS	66	L	S
Hondarawala 502	Ceylon	38	L	MS	76	L	S
H 106	Ceylon	47	L	MS	100	L	SS
H 501	Ceylon	0	D3	RR	0	D 10+SL	R
H 105	Ceylon	0	D2	RR	0	D4	RR
H 103	Ceylon	38	L	MS	80	L	SS
H 5	Ceylon	0·1	D	RR	0	D 3	RR
H 4	Ceylon	0·5	S	R	0·1	D 3+S	RR
Murungakayan 302	Ceylon	0·1	D+S	RR	0·3	D 4+S	R
Murungakayan 301	Ceylon	30	L	MS	100	L	SS
Murungakayan 104	Ceylon	0·3	S	R	1·0	D + L	RR
Murungakayan 3	Ceylon	2·1	S	MR	0·1	D 3	RR
Murungakayan 101	Ceylon	0·1	D3	RR	0	D 4	RR
Murungakayan 304	Ceylon	0	D 3	RR	0	D 5	RR
Murungan Samba 3081	Ceylon	0·5	D + S	R	0·1	D 3	RR
Periavellai 538	Ceylon	0·4	D + S	R	0·5	S	R
Pebifun	Indonesia	15	L	M	62	L	S
Remadja	Indonesia	0	—	RR	0	—	RR
SR 26 B	India	0	—	RR	0	—	RR
Sinnanayan 398	Ceylon	5·5	S	M	24	S	M
Samo	Indonesia	25	L	MS	58	L	S
Satika	Indonesia	22	L	MR	50	L	MS
Tjahaja T 27	Indonesia	0	—	RR	0	—	RR
Vannan	Ceylon	53	L	MS	100	L	SS
V. I. 28061	Ceylon	0·3	S	R	0·1	D 1	RR
Waner	Indonesia	23	L	MR	60	L	S
2–2–98	Japan	100	L	SS	100	L	SS
Ptb 10	India	42	L	MS	86	L	SS
Ptb 16	India	1·0	D + L	MR	13	D + L	M

Note.—* Lesion Type : L—Large Lesions
S—Small Brown Lesions
D—Dot-like Lesions

TABLE 2

Variety	Country of Origin	Percent Leaf Area Attacked	Lesion Type*	Grade of Resistance
Balamawi	Ceylon	100	L	SS
Bengawan B 27	Indonesia	0	D 2	RR
Dahanala 2014	Ceylon	80	L	S
Devaredderi 26081	Ceylon	100	L	SS
H 2	Ceylon	95	L	SS
Heenati 309	Ceylon	78	L	S
Heenati 310	Ceylon	85	L	SS
HMC 12	Burma	100	L	SS
HMC 20	Burma	72	L	S

TABLE 2—*contd.*

Variety	*Country of Origin*	*Percent Leaf Area Attacked*	*Lesion Type**	*Grade of Resistance*
Hondarawala 568	Ceylon	81	L	SS
Kaluheenati 3254	Ceylon	100	L	SS
Kurulutuduwi B 13	Ceylon	100	L	SS
Madael 137	Ceylon	100	L	SS
Mas M 24	Indonesia	100	L	SS
Mawi B 11	Ceylon	73	L	SS
Molagusamba g18	Ceylon	60	S	SS
Murunga 137	Ceylon	100	L	SS
Murunga 307	Ceylon	100	L	SS
Murunga 308	Ceylon	100	L	SS
Murungakayan 302	Ceylon	0	D 5	RR
Murungakayan 303	Ceylon	8	S	M
Murungakayan 304	Ceylon	0	D 6	RR
MYAC 104	Burma	0	D 10	RR
Oddavalan 2449/20	Ceylon	94	L	SS
Pachchaiperumal 2462/11	Ceylon	100	L	SS
Periavellai 538	Ceylon	10	S	M
Perillanel 26014	Ceylon	73	L	S
Podiwi a-8	Ceylon	98	L	SS
Pokkali	Ceylon	27	S	MS
Ptb 16	India	47	LS	—
Rathkarayal 3753	Ceylon	74	L	S
Siam 29	Siam	93	L	SS
Sinnanayan 398	Ceylon	85	L	SS
Sinnanayan 2208	Ceylon	83	L	SS
SR 26B	Ceylon	0	D1	RR
Suduheenati HF 9	Ceylon	100	L	SS
Suduheenati ICPY 15	Ceylon	100	L	SS
Suduheenati ICPY 19	Ceylon	100	L	SS
Suduwi 305	Ceylon	100	L	SS
Suduwi 306	Ceylon	100	L	SS
Sulai 301	Ceylon	39	S	MS
Sulai 27614	Ceylon	96	L	SS
Tadukan	Philippines	0	D1	RR
Tetep	Formosa	0	D 1	RR
Uvarvellai	Ceylon	72	L	SS
Vellai Perunel 28724	Ceylon	100	L	SS
Wannidahanala	Ceylon	100	L	SS
Pi–1	Japan	32	S	MS
Pi–2	Japan	70	LS	S
Pi–3	Japan	0	D 1	RR
Pi–4	Japan	0	D 1	RR
Asahi	Japan	71	L	S
Norin 22	Japan	52	LS	MS

Note.—* Lesion Type : L—Large Lesions
S—Small Brown Lesions
D—Dot-like Lesions

The general principles used for induction of blast under upland nursery conditions consist of heavy nitrogen fertilization in the form of a top dressing of ammonium sulphate, inhibition of the uptake of silica by growing the paddy under upland conditions and increasing the relative humidity within the plots by close spacing.

A point which requires clarification is the extent of the physiological changes induced, by growing under upland conditions and their relationship to the physiological status of the paddy when grown under inundated conditions. As the type of resistance usually associated with Indica varieties is due to the hypersensitivity of the invaded cells to the fungus (5), it will be necessary to consider these physiological changes in the host cells with respect to the effect of silica and nitrogen nutrition which has been found by Baba and others to influence the sensitivity of the paddy plant to *Piricularia oryzae* (3). Thus it will be necessary to determine whether varieties found to be resistant under upland conditions continue to exhibit resistance when grown in flooded soil. Data that will be published shortly indicate that the resistant varieties in Ceylon as evaluated under upland conditions show no change in resistance when grown under inundated conditions irrespective of the fertilizers given, soil types used and elevations at which the varieties are grown.

The technique so far described is an evaluation of resistance to leaf blast phase caused by *Piricularia oryzae*. The most serious aspect of the disease, however, is neck rot which is generally the dominant phase of the disease at higher elevations (over 1,500 ft.). Experiments which will be published later have shown a positive correlation between leaf blast assessed by this technique and neck rot under inundated conditions. This method of assessment of resistance therefore holds true for both leaf blast and neck rot caused by the blast fungus.

These experiments on disease resistance were conducted at only two stations (Karapincha and Peradeniya). The source of inoculum at the latter station was a fairly virulent strain which was brought in the disease straw from Karapincha, so that in all probability the same strains of *Piricularia oryzae* were used in these experiments. It is, however, possible that there exists in other parts of the island different physiological races of *Piricularia oryzae*. If such races are discovered it could be necessary to re-evaluate the resistance of the purelines tested.

DISCUSSION

According to the data presented in Tables 1 and 2 the varieties *SR 26B, Murungakayan* 302, 304, *V.I.* 28061 were very resistant, while the lines *Bengawan* 27, *Tjahaja* 27, and *Sigadis* 3443 showed exceptionally high resistance. Of the 71 pure lines tested, 17 were highly resistant. These did not differ in the degree of resistance from the Formosan *Indicas, Tetep* and *Tadukan,* which were used extensively by the Japanese in their breeding work. Of the remainder, two were very resistant, four fairly resistant, two rather susceptible and forty-six very susceptible.

According to preliminary observations all varieties graded as RR, R, MR in Tables 1 and 2 may be grown under inundated conditions and remain blast-free at high dosages of nitrogen. The performance of varieties graded M and MS under inundated conditions requires further investigations, while varieties graded S and SS should be used with caution especially at high dosages of nitrogen.

ACKNOWLEDGMENTS

The authors are deeply grateful to Mr. H. Okamoto for demonstration of the technique described and for his valuable guidance. They also thank Messrs. B. Suriyadasa and E. M. B. de Silva for their technical assistance in these experiments.

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FERTILIZER TRIALS IN CULTIVATORS' FIELDS IN CEYLON

By F. N. PONNAPERUMA

(*Department of Agriculture, Ceylon*)

FERTILIZER trials in cultivators' fields were first set down, in Ceylon, in 1955. The early trials which were limited in scale and exploratory in character served to indicate the methods and organization necessary for elaborate experimentation in cultivators' fields under Ceylon conditions.

With the experience of the first two seasons' trials a comprehensive scheme of fertilizer experiments in cultivators' fields was launched during the season October, 1956—March, 1957. One thousand seven hundred and twenty plots were laid down at 128 locations scattered in 63 Ranges (regional units) during this season. The scope of the trials was increased with each successive season, and to date has embraced the following kinds of experiments:— (i) forms and levels of nitrogen ; (ii) top dressing trials with ammonium sulphate ; (iii) forms of phosphate ; (iv) levels of nitrogen in conjunction with levels of phosphate ; (v) forms and levels of lime ; and (vi) complex trials involving levels of nitrogen, phosphorus and potassium. This paper describes the organization and techniques of the scheme and reports the results of the trials up to March, 1958.

THE SCHEME

The experiments were planned by the Chemistry Division of the Department of Agriculture and executed by the Extension Staff with the co-operation of the cultivators. The regional unit for these trials was the 'range', an administration unit with an average area of approximately 250 square miles. The range officers worked under the District Extension Officers but carried out these trials as part of their duties.

The administrative area rather than the soil type or phase was taken as the unit within which the trials were located at random

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because (1) the classification of hydromorphic soils has not proceeded far enough to permit accurate characterization of soil types under paddy land conditions, and (2) it was easier to administer the scheme if the existing extension organization was used.

PROCEDURE

Within each regional unit, a list of "yayas" (paddy tracts) that satisfied the following requirements was made each season:—(1) was more than 25 acres in area; (ii) had an assured water supply; and (iii) was not subject to excessive flood damage. From this list, five "yayas" were selected at randon. Within each of these "yayas", five holdings were selected at random. The details of the selected holdings were communicated to the Range Officer together with full instructions on the experiments and the randomizations of the treatments within each block. The Range Officer was instructed to arrange for the trial or trials in the first of these holdings. If for some reason this was not possible, he had instructions to proceed to the next.

The plot size was 35′ × 18½′ to give a nett harvested area of one-eightieth of an acre when a border of one foot was left out. If the necessary number of plots of this size could not be accommodated within a single "liyadde" (the smallest area in a paddy field bounded by ridges), he was allowed to reduce the plot size slightly but in no case was it to be less than 0.01 acre. In exceptional circumstances he was permitted to lay down the plots of a single block in two or more adjacent "liyaddes" provided that a whole number of plots lay within a "liyadde".

The plots were pegged out by the Range Officer (after the final levelling), and the small ridges by which the plots were bounded were made by the cultivators. The layout of the plots was checked in the field wherever possible. Failing that, sketches of the layout of the plots were scrutinized and necessary amendments suggested.

On satisfactory completion of the layout and receipt of information, on the probable date of sowing or transplanting, the fertilizers for each plot were mixed, weighed, packeted, numbered and despatched with full identification details. All that the Range Officer had to do was to take the parcel of fertilizer packets meant for a block at a particular location to the site of the experiment and apply the contents of each packet to the appropriate plot just before planting. Two thirds of the nitrogen was sent in a separate packet for topdressing 30 days before heading. The fertilizer was supplied free.

In the early stages of the scheme it was considered inexpedient to press for obviously desirable practices such as transplanting, etc. But with the increasing interest manifested in these trials it has become possible now to persuade the cultivators to adopt these practices. The necessary pest and disease control measures were carried out by the Range Officer or his assistants and a log book maintained for each trial.

Each plot was harvested separately, threshed, winnowed and weighed under the supervision of the Range Officer. A sample of paddy from each plot was sent in a air-tight container to the Chemistry Division for the determination of loss in weight on sun drying. The harvest figures were sent with the log book to the Chemistry Division where the statistical analysis was done after the necessary correction of each plot yield for loss on sun drying.

Soil samples representative of each block were taken before the application of fertilizers for laboratory studies for correlation with fertilizer response.

DESIGNS

The early experiments were set down as simple randomized blocks replicated in locations. Wherever the number of replicates permitted, the results of an experiment were analysed rangewise. Otherwise the results from two or more adjacent ranges were pooled. The current trials include complex N P K experiments.

RESULTS

Forms of nitrogen trials

Ammonium sulphate, the nitrogenous fertilizer most widely used on rice, has certain disadvantages. They are: (i) it aggravates the problem of hydrogen sulphide toxicity on rice soils low in easily reducible iron ; (ii) its manufacture in Ceylon presents certain difficulties ; (iii) its transportation charges per unit of nitrogen are about twice those of the newer fertilizers, urea and ammonium nitrate.

The forms of nitrogen trial was sent down in the form of a 3×3 factorial, replicated in 88 locations, in which the response to ammonium sulphate, urea and ammonium nitrate were studied at the three levels, 0, 30, and 60 lb. nitrogen per acre over a basal dressing of 40 lb. P_2O_5 and 50 lb. K_2O per acre. The soils were imperfectly to

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moderately well drained, strongly acid, lateritic clays and loams. The responses are summarized below:—

Form of Nitrogen	*Mean response (bushels/acre)*
Urea ..	.. 62·3
Ammonium nitrate	.. 63·5
Ammonium sulphate	.. 72·7
S.E. ..	.. 1·4

Levels of N. (lb./acre)	*Mean response (bushels/acre)*
0 ..	.. 57·4
30 ..	.. 62·4
60 ..	.. 69·7
S.E. ..	.. 1·4

The responses both to forms of nitrogen and to levels of nitrogen were very highly significant. The responses were also consistent over all locations. Ammonium sulphate gave the best response. The difference between urea and ammonium nitrate was not significant. The response to nitrogen over the range 0 to 60 lb. N per acre was linear and was 9 lb. paddy per lb. of N.

Forms-of-nitrogen trials which include ammonium phosphate are in progress in 46 locations.

Top dressing trials with ammonium sulphate

Large tracts of paddy under the major irrigation schemes receive no fertilizers. On these relatively productive soils it was surmised that top dressing with nitrogen alone, 30 days before heading, would give substantial increases in yield.

The responses to 0, 100 and 200 lb. per acre ammonium sulphate alone applied as a top dressing 30 days before heading were studied in randomized blocks of three plot replicated at three locations in each of six ranges. The results are summarized in Table I.

Table 1.—Top dressing trials : mean yields in bushels per acre

Range	*Ammonium sulphate in lb./acre* 0	100	200
Tissamaharama ..	43·53 ..	47·41 ..	51·51
Walawe Left Bank ..	37·70 ..	39·94 ..	43·85
Minipe	45·34 ..	53·12 ..	60·00
Minneriya	50·50 ..	60·65 ..	60·71
Nuwaragam Palata West ..	52·08 ..	80·20 ..	70·05
Tangalla	53·69 ..	66·09 ..	63·80

Top dressing with 100 lb. per acre ammonium sulphate gave a significant increase of 11.8 bushels per acre or 25 per cent over the six ranges. Top dressing with 200 lb. per acre ammonium sulphate gave a significant increase of 4.8 bushels per acre over top dressing with 100 lb. per acre ammonium sulphate in Tissamaharama, Walawe Left Bank and Minipe, while at Minneriya, Nuwaragam Palata West and Tangalla the higher level was not as good as the lower.

Forms of phosphate trials

The form of phosphatic fertilizer is relatively unimportant in lowland rice because the availability of phosphate is high in reduced soils. The cheapest form of phosphate may therefore be used on rice soils.

The response to five forms of phosphate, viz., rock phosphate (saphos), ordinary super phosphate, concentrated super-phosphate basis slag bonemeal (3/32″ grade) at 40 lb. per acre P_2O_5 over a basal dressing of 200 lb. per acre ammonium sulphate and 100 lb. per acre muriate of potash was studied in randomized blocks of six plots replicated at seven locations during the season April-September, 1957, and at 85 locations during October, 1957-March, 1958. The yields are summarized below:

April–September, 1957, Trials

Treatment	*Mean yield (bushels/acre)*
No phosphate	.. 40·74
Rock phosphate (Saphos) ..	.. 51·06
Ordinary super phosphate ..	.. 51·84
Concentrated super phosphate ..	.. 52·56
Basic slag	.. 52·26
Bone meal (3/32″) ..	.. 50·24
40 lb. P_2O_5 per acre ..	.. 51·59

There were no significant differences among the forms of phosphatic fertilizer. The response to 40 lb. P_2O_5 per acre was nearly 11 bushels per acre or 27 per cent over the control.

The season October, 1957-March, 1958, was a season of unusually heavy rainfall over the greater part of the island and disastrous floods in the Northern and Eastern parts. The results of the trials of this season are summarized in Table 2.

Table 2.—Mean yields in forms of phosphate trial of the season October, 1957–March, 1958, in bush./acre

District or Range	*No. of locations*	*Control*	*Rock phosphate*	*Ord. super phosphate*	*Conc. super phosphate*	*Basic s. ag*	*Bone meal*	*S.E.*	*Mean response to 40 lb. P_2O_5 per acre*
Colombo	11	36·31	36·13	36·38	37·72	39·20	37·86	1·15	1·2
Kalutara	8	22·89	26·80	25·85	25·69	26·30	21·97	1·44	2·5
Galle-Matara	4	37·99	39·26	43·26	43·87	40·96	38·71	3·03	3·3
Kegalle	6	41·74	42·04	40·07	47·18	44·44	44·84	2·28	2·0
Kandy	6	46·52	62·61	53·41	55·14	62·07	52·70	3·66	10·7
Mirigama	13	49·57	48·57	49·98	49·77	49·99	49·32	1·78	0
Minipe	5	53·98	51·75	53·27	51·31	46·95	52·04	2·52	2·9
Balangoda	5	40·94	54·75	56·07	50·18	55·54	56·81	3·54	13·7

There were no significant differences among the forms of phosphate in any of eight districts. The responses to 40 lb. P_2O_5 per acre during this unusual season were significant only in the Kandy District and Balangoda Range and were 10.7 and 13.7 bushels per acre respectively.

Trials with nitrogen and phosphorus

These trials were designed to obtain information on (*a*) the response to three levels of nitrogen, (*b*) the presence or absence of a response to phosphorus and (c) and N × P interaction.

The design was a 3 × 2 factorial in which the levels were : 0, 40 and 80 lb. nitrogen as ammonium sulphate ; and 0 and 40 lb. P_2O_5 as concentrated superphosphate. All plots received a basal dressing of 100 lb. per acre muriate of potash. The nitrogen was applied in two doses: one-third at planting and two-thirds 30 days before heading. The experiment was laid down in randomized block of six plots replicated at 8 locations in the season April-September, 1957, and at 56 locations in October, 1957-March, 1958.

The April-September, 1957, trials indicated very highly significant responses to the three levels of ammonium sulphate and to concentrated superphosphate at 40 lb. per acre P_2O_5. The N × P interaction was non-significant. The results are summarized in Tables 3 and 4.

Table 3.—Responses to nitrogen

Nitrogen (lb. /acre)	*Mean yield (bush/acre)*	*Increase (bush/acre)*	*Percentage increase over no nitrogen*
0	43·9	—	—
40	51·0	7·1	16·2
80	54·9	11·0	25·1

Table 4.—Responses to phosphorus

P_2O_5 (*lb./acre*)	*Mean yield*	*Increase*	*Percentage increase over no* P_2O_5
0	46·3	—	—
40	53·3	7·0	15·0

Forty pounds per acre nitrogen gave an average increase of 7.1 bushels per acre or 16.2 per cent, and 80 lb. N. gave an average increase of 11 bushels per acre or 25.1 per cent. Phosphorus at 40 lb. per acre P_2O_5 gave an increase of 7 bushels per acre or 15 per cent.

The same trial was laid down at 56 locations during the season October, 1857-March, 1958. Owing to flood damage the results from only 24 locations could be analysed. The results are summarized in Table 5.

Table 5.—Mean yield of October, 1957–March, 1958

District	*No. of locations*	*N, P. trials in bushels/acre*					
		Levels of N. lb./acre			*Levels of* P_2O_5 *lb./acre*		*Response to 40 lb.* P_2O_5
		1	*40*	*80*	*0*	*40*	
Colombo	6	30·2	31·4	26·9	28·1	30·3	2·2
Kalutara	4	26·9	25·3	26·5	26·7	25·5	−1·2
Kandy	5	60·5	65·7	70·4	59·7	71·5	11·8
Balangoda	4	49·1	53·8	49·4	45·8	55·7	9·9
Minipe	5	45·9	45·2	43·5	43·9	45·8	1·9

During this season of exceptionally heavy rainfall, the responses to levels of nitrogen were not significant in any one of the districts. The response to 40 lb. per acre P_2O_5 was significant in the Kandy District and Balangoda Range. It is interesting to note that responses of the same order to 40 lb. per acre P_2O_5 were obtained in the forms-of-phosphate trial of the same season. The relatively low yields of the Colombo and Kalutara Districts in these trials, as in the form of phosphate trials, reflect the operation of some limiting factor in these two districts. One of these was blast disease which was aggravated by fertilizers.

The scope of these trials has been expanded to include three levels of N, P & K. Eighty-six of these 3 × 3 confounded factorial trials are in progress.

Liming trials

Liming trials in cultivators' fields gave spectacular results. Average responses as high as 20 bushels per acre to a six-tons-per acre application of slaked lime were obtained on imperfectly to moderately well drained acid lateritic clays.

Lime was first used as a remedy for a physiological disease of rice known as "bronzing" which is believed to be associated with excess soluble iron. This disease occurs extensively on the strongly acid lateritic paddy fields of the ultra-wet zone of Ceylon. The striking response of rice to liming prompted the study of the use of lime as an ameliorant for acid lateritic soils in cultivators' fields.

The experiments were designed to study the response of rice to slaked coral lime with and without nitrogen, over a basal dressing of phosphorus and potassium under the cultural conditions that obtain in two ranges where the soils were imperfectly to moderately well drained acid lateritic clays and loams. Nitrogen was included in the trials to ascertain to what extent the benefits of liming could be attributed to increased ammonification brought about by a favourable soil reaction. The treatments were:

1. No lime, no nitrogen ($L_0 N_0$)
2. Six tons per acre slaked lime, no nitrogen $L_1 N_0$)
3. No lime, 40 lb. acre N as ammonium sulphate ($L_0 N_1$)
4. Six tons per acre slaked lime, 40 lb. per acre N as ammonium sulphate ($L_1 N_1$).

The trial was laid down in the season Oct. '57 — March, '58 in randomized blocks of four plots replicated in locations within the range. The slaked lime was applied uniformly over the plots after the final levelling and thoroughly incorporated into the soil two weeks before planting. All plots received a dressing of 40 lb. acre $P_2 O_5$ as concentrated super phosphate and 50 lb. per acre $K_2 O$ as muriate of potash.

The results are summarized in Table 6.

Table 6.—Results of Liming Trials

Range	*No. of Locations*	*Mean yields in bushels per acre*				*S. E.*
		$L_1 N_1$	$L_1 N_1$	$L_1 N_1$		
Mirigama ..	13 ..	40·6 ..	60·6 ..	43·7 ..	53·3 ..	1·8
Kamburupitiya ..	6 ..	36·9 ..	45·9 ..	37·7 ..	45·2 ..	1·7

In both ranges, the response to lime was very highly significant while the response to nitrogen was not significant. In Mirigama the average response to lime was 16.5 bushels per acre; at Kamburupitiya, it was 8.3 bushels per acre. In Mirigama there was a severe lime and nitrogen interaction. Lime in the absence of nitrogen gave

an increase of 20.0 bushels per acre; in the presence of lime the response was reduced to 12.9 bushels per acre.

The trials in Kamburupitiya were repeated in the subsequent season to study the residual effect of lime. The results are summarized below:

	$L_0 N_0$	$L_1 N_0$	$L_0 N_1$	$L_1 N_1$
Mean yield in bushels/acre	42·14	46·58	34·37	41·14

The mean response to lime was 11.2 bushels per acre. The result suggest that nitrogen is superfluous in at least the first two seasons following liming.

The results of trials in cultivators' fields confirm the findings at experiment stations that liming is a fruitful amendment for the strongly acid lateritic paddy soils of the low country wet zone of Ceylon, and that its effect cannot be attributed to increased availability of nitrogen.

It is still too early to assess the practical significance of these findings in Ceylon's drive for self sufficiency in rice. The potential increase in rice production can, however, be gauged from the fact that there are approximately 200,000 acres of paddy which are likely to show a response to lime.

Liming trials comprising residual effects of lime, forms of lime (slaked coral lime, ground coral limestone, ground dolomite) lime and N, and lime and P trials are in progress at 140 locations.

SUMMARY

Fertilizer trials in cultivators' fields have been conducted in Ceylon with the co-operation of the extension staff and cultivators since 1955.

On moderately well-drained, acid lateritic soils, ammonium sulphate was superior to urea and ammonium nitrate; there was no appreciable difference between urea and ammonium nitrate. On these soils the response to nitrogen was linear in the range 0-60 lb. nitrogen per acre and averaged 9 lb. paddy per lb. of nitrogen.

Top dressing with 100 lb. ammonium sulphate of unfertilized fields, in the dry zone, with an assured water supply, gave an increase of nearly 12 bushels per acre or 25 per cent.

There were no significant differences among the following phosphatic fertilizers : rock phosphate, ordinary superphosphate, concentrated

superphosphate, basic slag, and bonemeal. The response to 40 lb. per acre P_2O_5 ranged from 7-11 bushels per acre or approximately 25 per cent on the paddy soils of the mid country and the dry zone. The responses obtained in the low-country, ultra-wet zone were smaller and non-significant.

In trials with N and P, significant average responses of the order of 7 bushels per acre (16 per cent) and 11 bushels per acre (25 per cent) to 40 lbs. per acre N and to 80 lbs. per acre N, respectively, were obtained. The average response to 40 lb. per acre P_2O_5 in these trials was 7 bushels per acre or 15 per cent. There were no responses to N or P on the poorly and imperfectly drained soils of the low-country, ultra-wet zone.

The most striking results were obtained in the liming trials on the imperfectly and moderately well-drained, strongly acid, lateritic soils of the ultra-wet zone. The direct average effect of a six-tons-per acre application of slaked lime, in the absence of added nitrogen, was as high as 20 bushels per acre: the residual effect during the shorter subsequent season was 11 bushels per acre. Nitrogen appeared to be superfluous in the season of lime application.

MECHANICAL ROW SEEDING OF SWAMP RICE

By S. THAMBIAYAH

(*Department of Agriculture, Ceylon*)

VARIOUS factors including shortage of labour and excess or insufficiency of water permit the adoption of transplanting only on a small fraction of Ceylon's rice acreage. Even with careful preparatory tillage, weed control on the broadcast extent of nearly 1,158,000 acres representing over 90% of the island's rice acreage, is relatively inefficient.

Row seeding followed by intercultivation with the Japanese rotary weeder provides completely satisfactory weed control. In departmental trials, yields from row-seeded plots have often been higher than under conditions of transplanting. Mechanical devices for row-seeding swamp rice have been under investigation by Dr. S. Nizeki, C-Plan Adviser on Rice Implements, and are discussed herein.

Methods investigated included :

(1) Continuous drop seeding.
(2) Avenue spot seeding.
(3) Square spot seeding.
(4) Strip seeding.

Three prototype seeders were built by him and tested.

FRAME-TYPE SQUARE PLANTER

The Frame-type square planter (Fig. 1) consists of a heptagonal skeletal prismatic wooden frame divided into 5 sections along its length. Each section carries a unit comprising a seed container with a delivery funnel and a circular metal disc with seven radial extensions on which seed cups are fixed. The seed containers are slung on a loose central axle, and the circular plates bearing the cups are fixed

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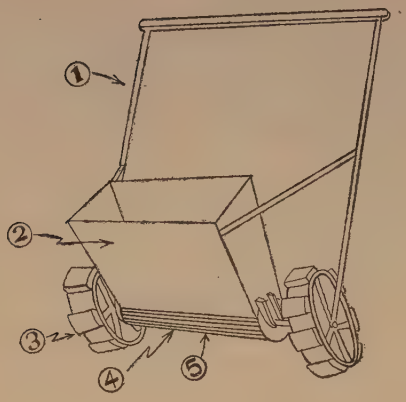
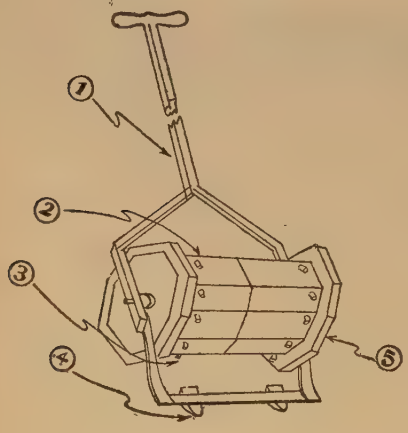


(1) Handle
(2) Seed box
(3) Wheel
(4) Seed drum
(5) Metal slip bush

to the frame through tube shafts. The frame can be rolled on the soil surface either by pushing forward or pulling backwards with a handle. As the frame is rolled the seed cups pick up the seeds in the container and deliver them through the funnel thereby depositing about twenty seeds per spot. The spots of seeds can be laid either on the square (10″ × 10″) or in avenues (1″ × 6″ to 8″).



(1) Handle
(2) Octagonal drum
(3) Seed delivery tube
(4) Furrow opener shoe
(5) Wooden rim

DRUM-TYPE SEEDER

In the Drum-type Seeder (Fig. 2) an octagonal metal drum with two octagonal wooden rims acting as wheels give the necessary clearance and form the main unit. The drum itself is made in two halves and could be opened for filling seed. On the eight faces of the

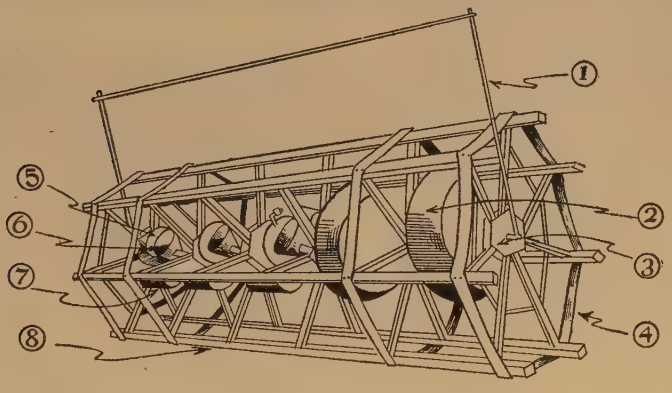
drum are placed 16 tube exits to deliver the seeds. The internal surface of the drum has catch projections and ribs so arranged to direct seeds to the delivery tube exits. The two halves of the drum are so meshed that it is possible to alter spacing by about 2″ if necessary. The axle with a handle and furrow opener shoes bear the drum. The seeder is a push type with the wheel rims acting as markers.

SEEDER FOR STRIP SEEDING

In investigations caried out it was found that seeding in strips (6″ 8″ wide with 8 to 15″ borders) may be advantageous. In this type of seeding it was possible to press the seeds into the surface gently with a wire gauze roller ; this prevents bird damage and seed drift in case of light showers.

The design for this seeder (Fig. 3) consists of a groved roller fixed under a seed box in a manner, that, as the roller rotates by the power transmitted through the two wheels when pushed, seed delivery occurs. Metal slip bushes can be moved on the roller to alter spacing of strips.

Frame Type Square Planter



(1) Handle
(2) Seed container cover
(3) Loose central axle
(4) Canvas bands
(5) Circular plate on which cups are fixed
(6) Funnel
(7) Seed container
(8) Wooden frame

CEYLON'S AGRICULTURAL PROGRESS IN 1958

By M. F. CHANDRARATNA

(*Director of Agriculture*)

In the year 1958 the land use policy of the Department of Agriculture was restated with increased emphasis on livestock production and with closer integration of crops with animal husbandry. This restatement of policy was reflected in a re-orientation of Department-sponsored dry-farming schemes and of crop programmes on Departmental farms. The creation within the Department of a Division charged with the responsibility for framing land-use plans and programmes was a necessary corollary to the new approach.

During the year, the Department's research achievements and extention efforts made a marked impression on the Island's crop and livestock production. The expansion in crop acreages and the rise in acre yields are particularly remarkable in view of the communal troubles that obstructed extension activities and of the occurrence of a rainfall distribution that did not favour crop growth.

The performance of the rice crop was particularly gratifying. Acre yields of rice both in *Maha* and *Yala* seasons were the highest ever recorded in Ceylon. The Island average for *Maha* 1957-58 was 34.8 bushels of paddy per acre ; the highest *Maha* yield recorded previously was 32.7 bushels per acre in 1956-57. This increase in acre yields occurred over a period when the cultivated acreage expanded from 778,000 in *Maha* 1956-57 to 838,000 in *Maha* 1957-58, and when presumably much marginal land went under cultivation. In *Yala* 1958 the Island's average yield reached th unprecedented figure of 35.5 bushels per acre ; the highest acre yield ever obtained before in *Yala* season was 33.5. It is noteworthy that this rise in the average yield resulted from a consistent yield increase over practically the whole of Ceylon's rice acreage ; Matale was the only one of the twenty districts which failed to register a rise in yield over the previous *Yala*.

It is relevant at this stage to examine the potentialities for self-sufficiency in rice. Using the population projection prepared by the

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Department of Census and Statistics on the basis of present mortality rates and of decline in the crude birth rate to 35.0, one may assume that at the end of the five-year period commencing 1958, Ceylon's population would approximate 10 millions. On the assumption of a 68% milling out-turn of rice on paddy, a paddy bushel weight of 45 lb. and a per capita consumption of 198 lb. of rice per annum, the requirements of a population of 10 millions would be 64.7 million bushels of paddy. With an annual harvested rice acreage of 1.1 million, an average yield of 58.9 bushels per acre for the whole Island would be needed to provide these requirements. It is gratifying to record that in 1958 this figure was exceeded in three districts in *Maha* and in one district in *Yala*. The Polonnaruwa, Badulla and Nuwara Eliya districts recorded average yields of 59.3, 61.2, and 66.6 bushels per acre respectively. In *Maha* 1957-58 ; the average acre yield for the Polonnaruwa district in *Yala* 1958 was 62.2.

The following figures illustrate the striking advances in the improvement of Ceylon's rice yields in the last three years.

Average Yields of Paddy in Bushels per Acre

Maha Season			*Yala Season*		
1955-56	*1956-57*	*1957-58*	*1956*	*1957*	*1958*
30.9	32.7	34.8	28.4	31.8	35.5

The chief factors that have contributed to the striking rice yields recorded in 1958 are heavy fertilisation and the use of high-response, blast-resistant varieties that permit efficient fertilizer exploitation.

The following figures for fertilizers purchased from co-operatives illustrate the progress in fertilizer use :—

Year	*Fertilizers Purchased*
1956	14,204 tons
1957	17,048 „
1958	19,425 „

The complete success of the *yaya* scheme of seed paddy production which was inaugurated in 1957 made large quantities of certified seed paddy available to farmers. The total production in Private Seed

Farms during *Maha* 1957-58 was 64,180 bushels, of which 57,880 bushels were sold to cultivators. This figure represents nearly a 100 per cent. increase over the quantity sold from private seed Farms in 1957. During the *Yala* 1958, 38,181 bushels of certified seed were sold to cultivators from Private Seed Farms. In *Maha* 1958-59, the private Seed Farm acreage has been raised to 6,083 and nearly 150,000 bushels of pure seed are expected from the *Maha* 1958-59 harvest.

In a large part of Ceylon's rice acreage, heavy weed infestation obstructs efficient fertilizer action and constitutes a serious limiting factor to the raising of rice yields. The position should improve rapidly with the successful completion of the implements project at Welisara. The Workshop which has gone into production is designed to turn out annually 30,000 ploughs, 30,000 harrows, 200,000 rotary weeders and 20,000 row seeders.

Sugar Cane

The planting of the first year of 1,600 acres under the Kantalai sugar project was completed according to schedule. Never before in this country has a planting of this magnitude been undertaken and implemented by a Government department. There is no reason to doubt that the vacuum-pan factory will be completed in 1959 to permit the crushing of this harvest. The out-turn of 5,000—6,000 tons expected in 1959 will represent the first production of sugar of the quality "plantation white" in this country.

Cotton

The 1958 acreage of over 6,000 represents the largest area ever grown in cotton in this country. The whole of the extent was planted in the new hybrid HC 101. This selection represented such a striking improvement on the variety previously under issue that it was possible to request the Wellawatta Mills to raise the purchase price per cwt. of seed cotton from Rs. 56.00 to Rs. 69.00. Moreover this season's production would be of a magnitude that would nearly saturate the requirements of the Wellawatta Mills in medium staples, and the need importing cotton of this staple length may not arise.

Potato

Efficient wilt and virus control by the Research Co-ordinator, Rahangala contributed considerably to the success of the potato project. Yields at Rahangala averaged seven tons per acre.

There was a rapid expansion in the potato acreage in 1957-58.

All arangements have been made to establish a hundred-acre potato seed multiplication station at each of the following locations in the Nuwara-Eliya District, Kandapola, Galpalama, Moon Plains, Ragala, Elk Plains and Nuwara Eliya. This acreage should provide adequate quantities of seed in 1961 for planting the 8,000 acres needed for Ceylon's self sufficiency potatoes.

Tobacco

An acreage of 7,000 is needed for self-sufficiency in cigarette tobacco. The extent under cultivation in 1957 approximated 5,000 acres. It is the Department's policy to establish the additional acreage of 2,000 in the dry zone in *yala* in rotation with the paddy crop. Despite the difficulties presented by communal disturbances in May, 163 acres were planted in the Polonnaruwa District.

Pastures and Dairying

Progress on the Tamankaduwa project initiated last year was considerable. The natural *villu* pastures in this area cover nearly 20,000 acres and can maintain nearly 12,000 cows for nine months in the year. *Brachiaria brizantha* pastures on high land will provide feed during the period November to February when floods submerge the *villus*. The establishment of a herd of 5,000 milking cows and ancillary follower and fattening units is envisaged. The project is phased over six years. The capital expenditure in this period totals nearly six million rupees and an annual recurrent expenditure of 0.4 millions is anticipated. When the completed project commences functioning, the total annual yield of milk will approximate five million pints, and the annual income will exceed 1.1 million rupees. Both production and profits would rise with progressive improvement of the herd.

Poultry

The increase in the hatching capacity provided by the Department has been phenomenal over the period 1957-58 : the hatching capacity

per month has risen from 18,000 eggs to 88,900 eggs. There will be a further rise of 58,800 eggs per month in 1959 bringing the total hatching capacity provided by the Department to nearly 150,000. It is anticipated that Ceylon's egg imports will cease completely when this increase in hatching capacity makes its full impact on the Island's poultry population. As matters stand, the Department's efforts in this field have already made a profound impression on import figures : egg imports which averaged 27-30 millions per year in the 5-year period preceding 1958, dropped to 19 millions in 1958. It is anticipated that egg imports will almost completely cease by the end of 1959.

Scarcity of grain which composes 40% of poultry feed constitutes a serious limiting factor to the expansion of egg production, and plans for the promotion of grain production by peasants, and for the organization of Government controlled poultry food stores are being framed.

Tractor Services

The agricultural tractor services which this Department was obliged to take over from the Department of Food Production in October, 1956 continued to be operated without marked improvement in efficiency and heavy financial less till the end of 1957. In 1958 a scheme of reorganization formulated by the Superintending Mechanical Engineer and the Chief Accountant was implemented. The chief feature of the scheme was the decentralisation of the tractor units and their operation by Paddy Extension Officers whose intimacy with the problems and the requirements of their areas permitted the efficient exploitation of the units. Minor repairs were effected by six Field Repair Depots at Kilinochchi, Polonnaruwa, Kekirawa, Gannoruwa, Bandarawela and Hambantota. Major repairs and everhauls continued to be the responsibility of the Kangaroo Tractor Station, Anuradhapura.

Receipts for the period commencing with the implementation of the reorganised scheme and ending January, 1959 were in excess of expenditure; this appeared to be the first occasion since the inauguration of the services by the Department of Food Production that revenue had exceeded expenditure. This period coincided with the cultivation season : hence the relative profit. The problem of finding remunerative work for the tractors during the off season is being solved by the purchase of trailers for haulage. The scheme thus provides for the continuous use of tractors throughout the year.

Rice Extension

The data summarized below illustrate the striking success achieved in the promotion of improved practices:

Paddy acreages under improved practices

	Yala 1958	*Maha 1957–58*	*Yala 1958*	*Maha 1958–59*
Acreage cultivated	395,154	740,866	520,959	793,908
Transplanted :				
(*a*) by normal method	6,886	70,920	12,406	69,438
(*b*) in rows	2,501	16,851	4,473	24,671
Row seeded	7,449	11,208	11,435	18,529
Broadcast and harrowed	13,213	23,885	19,892	25,651
Weeded :				
(*a*) by hand	68,769	132,871	98,118	142,562
(*b*) with rotary weeder	5,528	18,059	15,907	43,200
Fertilized	123,268	236,941	148,437	242,859
Tractor ploughed	—	175,446	85,287	250,801
Under purelines	64,477	203,350	80,644	—

Fertilizer Use with Rice

In the final analysis, the yield problem in rice resolves itself into—

(*a*) the use of optimum fertilizer dressings

(*b*) the use of high-response varieties that allow the most efficient exploitation of fertilizers, and

(*c*) the elemination of factors that obstruct efficient fertilizer action, e.g. weed infestation.

Negative factors, e.g., the elimination of pest hazards, of course, demand attention, but it is evident that the rational use of fertilizers provides the most fruitful method of yield increase in rice.

Apart from the expansion of the fertilized acreage from 360,209 in 1957 to 391,296 in 1958, heavier dressings of fertilizers were used in 1958. The paddy crop received 453,934 cwt. of fertilizer in 1958 as against 360,940 cwt. in 1957 : the intensity of fertilization was 1.2 cwt. per acre as against 1.0 in 1957.

Information relating to fertilizer use is presented District-wise in Table 1. The fraction of the total cultivated acreage that received fertilizers in 1958 was 37.3% as against 31.7% in 1957. Fertilizer use was most extensive in the Kegalle District where the extents fertilized were 65.3% and 80.6% in *yala* 1958 and *maha* 1958/59 respectively.

TABLE I—USE OF FERTILIZERS WITH PADDY IN 1958

District	*Quantity of Fertilizers sold to Farmers in Cwt.*			*YALA 1958*		*MAHA 1958–59*		*Total for 1958*	
	Through Co-operative Societies	*Through other Channels*	*Total*	*Acreage cultivated*	*Acreage fertilized*	*Acreage cultivated*	*Acreage fertilized*	*Acreage cultivated*	*Acreage fertilized*
1. Colombo	41,135	7,696	48,831	30,942	13,143	53,806	26,108	84,748	39,251
2. Kalutara	11,574	2,720	14,294	38,427	12,554	38,957	16,000	77,384	28,554
3. Kandy	40,049	10,644	50,693	31,486	11,225	36,571	19,081	68,057	30,306
4. Matale	9,882	2,351	12,233	9,393	3,880	10,275	3,482	19,668	7,362
5. Nuwara Eliya	3,990	865	4,855	8,035	1,334	2,510	1,903	10,545	3,237
6. Galle	31,757	200	31,957	50,037	29,147	31,677	25,075	81,714	54,222
7. Matara	35,780	8,278	44,058	42,780	17,073	44,957	19,893	87 737	36,966
8. Hambantota	9,824	2,322	12,146	25,006	2,674	31,446	4,958	56,452	7,632
9. Jaffna	24,800	5,400	30,200	5,830	2,900	60,000	12,200	65,830	15,100
10. Mannar	2,650	218	2,868	762	Nil	25,200	2,548	25,962	2,548
11. Vavuniya	1,240	350	1,590	5,290	247	37,102	1,088	42,392	1,335
12. Trincomalee	620	400	1,020	19,102	140	36,827	300	55,929	440
13. Batticaloa	18,320	3,023	21,343	50,641	4,564	108,350	8,826	158,991	13,390
14. Kurunegala	76,514	7,474	83,988	81,589	9,730	102,728	42,154	184,317	51,984
15. Puttalam	5,572	6,360	11,932	6,773	889	16,453	7,575	23,226	8,464
16. Anuradhapura	311	578	889	29,754	634	34,265	976	64,019	1,610
17. Polonnaruwa	14,003	603	13,606	28,400	5,604	32,159	9,210	60,559	14,814
18. Badulla	5,187	119	5,306	11,516	633	33,185	5,190	44,701	5,823
19. Ratnapura	13,344	823	14,167	23,537	5,360	19,391	8,869	42,928	14,229
20. Kegalle	42,986	4,993	47,979	21,659	14,183	28,049	22,613	49,708	36,796
	388,508	65,427	453,935	520,959	148,438	793,908	242,859	1,314,867	491,297

Use of Improved Rice Varieties

In the 1957-58 *Maha* season, 64,180 bushels of certified pureline seed paddy were purchased. The quantities purchased are tabulated below:

Purchase of Certified Pureline Seed Paddy from Private Seed Farms, Maha 1957–58

District	*PTB 16*	*Podivi (a—8)*	*Mavi (B—11)*	*Murungakayan 302*	*Murungakayan 104*	*H—105*	*Murungakayan 3*	*Total*
Colombo	3,100	400	—	—	—	—	—	3,500
Kandy	—	686	1,365	6,145	—	—	—	8,196
Matale	—	—	—	1,315½	—	—	—	1,315½
Galle	—	—	—	122	—	—	—	122
Matara	—	—	—	159	—	—	—	159
Hambantota	—	—	—	—	2,074	3,072	—	5,146
Jaffna	—	—	—	10,144	—	—	—	10,144
Mannar	—	—	—	7,076	—	—	—	7,076
Vavuniya	—	—	—	3,792	—	—	—	3,792
Batticaloa	—	—	—	2,565	—	—	—	2,565
Trincomalee	—	—	—	1,050	—	—	—	1,050
Kurunegala	—	—	—	—	—	—	2,576	2,576
Puttalam	—	—	—	311½	—	—	—	311½
Anuradhapura	—	—	—	5,195	—	—	—	5,195
Polonnaruwa	—	—	—	5,506	—	—	—	5,506
Badulla	—	—	—	5,389	—	—	—	5,389
Ratnapura	—	—	—	1,013	—	—	—	1,013
Kegalle	1,010	114	—	—	—	—	—	1,124
	4,110	1,100	1,365	49,783	2,074	3,072	2,576	64,180

In the 1958-59 *Maha* season, 57,800 bushels of certified pureline seed were sold to peasants from the stock purchased from 1957-58 maha crops. It is gratifying to note that this figure represent nearly a 100 percent increase over the quantity (24,384 bushels) of pureline seed sold to peasants from private seed farms in 1957. This achievement is particularly noteworthy as this is the first time that certified seed paddy subjected to rigorous laboratory tests has been made available to peasants.

About 6,300 bushels of seed purchased were not sold as the viability has deteriorated in storage. The quantity of seed remained unsold represents less than 10 per cent. of the total stock.

Sales of Certified Pureline Seed Paddy to Cultivators in Maha 1958-59

District	PTB 16	Podivi (a—8)	Murungakayan 302	Murungakayan 104	H—105	Murungakayan	Total
Colombo	564	—	—	—	—	—	564
Kandy	—	200	5,637	—	—	—	5,837
Matale	—	—	1,351½	—	—	—	1,351½
Galle	—	—	46	—	—	—	46
Matara	—	—	159	—	—	—	159
Hambantota	—	—	—	2,004	2,922	—	4,926
Jaffna	—	—	9,700	—	—	—	9,700
Mannar	—	—	7,076	—	—	—	7,076
Vavuniya	—	—	3,792	—	—	—	3,792
Batticaloa	—	—	2,565	—	—	—	2,565
Trincomalee	—	—	1,050	—	—	—	1,050
Kurunegala	—	—	—	—	—	2,576	2,576
Puttalam	—	—	311½	—	—	—	311½
Anuradhapura	—	—	5,195	—	—	—	5,195
Polonnaruwa	—	—	5,505	—	—	—	5,505
Badulla	—	—	5,350	—	—	—	5,350
Ratnapura	—	—	752	—	—	—	752
Kegalla	1,010	114	—	—	—	—	1,124
	1,574	314	48,490	2,004	2,922	2,576	57,880

In the 1958 *Yala* season, 38,181 bushels of certified pureline seed were purchased from private seed farms. Details of purchases are given below.

Purchases of Certified Pureline Seed Paddy from Private Seed Forms, Yala 1958

District	Murungakayan 302	Pachchaiperumal 2461/11	ICPY 15	H—501	Murungakayan 3	Wannidahanala, 1	Total
Colombo	300	—	—	—	—	—	300
Kalutara	44	—	—	—	—	—	44
Kandy	996	1,770	—	—	—	—	2,766
Matale	—	371	52	—	—	—	423
Galle	—	—	—	100	—	—	100
Matara	376	—	—	470	—	—	846
Hambantota	—	4,004	—	—	—	—	4,004
Jaffna	—	1,800	—	—	—	—	1,800
Mannar	—	—	—	—	—	—	—
Vavuniya	—	3,468	—	—	—	—	3,468
Batticaloa	—	1,855	—	—	—	—	1,855
Trincomalee	—	1,420	—	—	—	—	1,420
Kurunegala	—	—	—	—	2,252	414	2,666
Puttalam	54	790	—	—	—	976	1,820
Anuradhapura	1	10,944	—	—	—	—	10,944
Polonnaruwa	—	4,312	—	—	—	—	4,312
Badulla	—	132	—	—	—	—	132
Ratnapura	845	—	—	—	—	—	845
Kegalla	436	—	—	—	—	—	436
	3,051	30,866	52	570	2,252	1,390	38,181

In the 1958-59 *Maha* season, 6,083 acres have been established under private seed farms, out of which 4,597 acres are under popular pureline Murungakayan 302. The area under Podivi (a-8) and Mavi (B-11) has been greatly reduced as these two varieties are susceptible to blast. These two varieties will be gradually replaced with Ptb 16 which is moderately resistant to blast disease and has a higher fertilizer response.

Acreage established under Private Seed Farms during Maha, 1958–59

District	*PTB 16*	*M302/ A8*	*H501*	*M3*	—	*B11*	*H105*	*M104*	*Hondrawala 501*	*Total*
Kegalle	238	—	—	—	—	—	—	—	—	238
Kalutara	—	13	—	—	—	—	—	—	5	18
Matara	—	90	—	54	—	—	—	—	—	144
Matale	—	289	—	—	—	—	—	—	—	289
Puttalam	—	—	163	—	97	—	—	—	—	260
Galle	—	—	—	74	—	—	—	—	—	74
Vavuniya	—	276	—	—	—	—	—	—	—	276
Kandy	84	232	50	—	—	75	—	—	—	441
Trincomalee	—	199	—	—	—	—	—	—	—	199
Batticaloa	—	950	—	—	—	—	—	—	—	950
Ratnapura	11	142	27	—	—	—	—	—	—	180
Kurunegala	33	—	23	—	156	—	—	—	—	212
Hambantota	25	—	—	—	—	—	60	60	—	145
Jaffna	—	1,200	—	—	—	—	—	—	—	1,200
Mannar	—	274	—	—	—	—	—	—	—	274
Polonnaruwa	—	195	—	—	—	—	—	—	—	195
Colombo	217	14	34	—	—	—	—	—	—	265
Badulla	—	318	—	—	—	—	—	—	—	318
Anuradhapura	—	405	—	—	—	—	—	—	—	405
	608	4,597	297	128	253	75	60	60	5	6,083

It is expected that 150,000 bushels of certified pureline seed from 1958-59 *Maha* planting.

Paddy Yields in 1958

There was a steady increase both in the cultivated extent and in the average yield per acre for the Island as a whole. The acreage cultivated rose from 778.000 in *Maha* 1957 to 838,000 in *Maha* 1958. In the same period the average yield also rose from 33 bushels per acre in 1957 to almost 35 bushels per acre in 1958—the highest average yield per acre on record. Of the individual district yields, the most remarkable was that of Mannar district which leapt from 22 bushels to 47 bushels per acre—an increase of over 100 per cent. Large, though less spectacular, increases were also recorded both in the Badulla and Nuwara Eliya districts.

The provisional *Yala* yields are even more encouraging. The average yield in *Yala* for the Island has, for the past six years, been consistently below that for *Maha*. But this year, the average yield of 35.5 bushels/acre has not only caught up with the *Maha* yield but has actually exceeded it. It is noteworthy that this increase in the average yield did not come about by a large increase in a few districts but by a consistent increase in almost every district.

Table 2—Average Yields of Paddy in Maha 1957–58

	Average Yield (lb. per acre)	*Standard Error (lb. per acre)*	*Standard Error per cent.*
Colombo District	1,430	70·15	4·90
Kalutara District	1,090	49·05	4·50
Western Province	1,310	50·80	4·03
Galle District	1,135	31·75	2·79
Matara District	1,325	73·25	5·52
Hambantota District	1,740	84·60	4·86
Southern Province	1,380	37·80	2·70
Ratnapura District	1,125	62·88	5·58
Kegalle District	2,165	58·35	2·69
Sabaragamuwa Province	1,661	100·85	6·13
Kandy District	2,030	130·50	6·42
Matale District	2,000	99·20	4·98
Nuwara Eliya District	2,995	329·55	11·00
Central Province	2,248	104·40	4·45
Batticaloa District	1,425	111·60	7·83
Trincomalee District	1,375	174·70	12·70
Eastern Province	1,412	84·30	3·01
Jaffna District	1,145	14·80	1·29
Mannar District	2,110	140·10	6·63
Vavuniya District	1,400	182·70	13·05
Northern Province	1,371	55·20	3·55
Anuradhapura District	1,250	91·05	7·28
Polonnaruwa District	2,670	345·40	12·93
North-Central Province	2,033	194·90	9·92
Kurunegala District	1,465	29·30	2·00
Puttalam-Chilaw Districts	1,080	64·15	5·93
North-Western Province	1,432	27·40	2·15
Badulla District	2,755	263·95	9·58
Uva Province	2,755	263·95	9·58
Island	1,567	26·62	1·69

Table 3—Average Yields of Paddy in Yala 1958

District	*Average Yield (lb. per acre)*	
	Yala, 1958	*Yala, 1957*
1. Colombo	1,335 ..	1,110
2. Kalutara	1,290 ..	1,045
3. Galle	1,210 ..	1,140
4. Matara	1,345 ..	1,175
5. Hambantota	1,845 ..	1,710
6. Ratnapura	1,215 ..	1,199
7. Kegalle	1,330 ..	1,235
8. Kandy	1,795 ..	1,700
9. Matale	1,530 ..	1,755
10. Nuwara Eliya ..	* ..	*
11. Batticaloa	1,820 ..	1,670
12. Trincomalee	2,515 ..	1,560
13. Jaffna	* ..	1,385
14. Mannar	* ..	*
15. Vavuniya	* ..	1,824
16. Kurunegala	1,410 ..	1,675
17. Puttalam—Chilaw ..	1,215 ..	*
18. Anuradhapura ..	* ..	2,145
19. Polonnaruwa ..	2,800 ..	2,650
20. Badulla	* ..	1,485
Island	1,598 ..	1,490

* Not yet available.

METEOROLOGICAL REPORT

SUMMARY FOR OCTOBER-DECEMBER, 1958

UNSETTLED conditions caused by a depression in the Bay of Bengal gave widespread rain over the Island from 5th to 9th October. Thunder activity resulted in fairly general in during the rest of the month. The greater monthly totals of rainfall which exceeded 40 inches were confined to the south-western slopes of the central hills. The lowest totals were recorded in the east and southeast. The larger excesses of rainfall of the order (or 15 to 20 inches) were experienced in the southwest quarter, while the larger deficits (of the order of 5 to 10 inches) occurred in the north eastern hill-country. There were 49 daily falls of over 5 inches, the highest being 9.24 inches at Sunderland Estate on the 24th.

Intermonsoon thunder activity was well in evidence during November, with faily widespread thundershowers which were distributed through the month. From the 19th to 21st the weather became unsettled due to a depression in the Bay of Bengal, resulting in widespread rain which was moderately heavy in the north. Greater monthly totals of rainfall during the month occurred in the south-west quarter, and were of the order of 15 to 20 inches, the greatest being 24.80 inches at Panangala. Outside the south-west quarter the rainfall ranged mainly between 5 and 15 inches. The rainfall over the Island was chiefly below normal, the bigger deficits being of the order of 5 to 10 inches. Excesses occurred in places in the south-west quarter and neighbourhood, the biggest excesses being 10.30 inches at Matara. There were about 20 daily falls over 5 inches. The highest being 6.82 inches at Avissawella Estate on the 30th.

North-east monsoon weather prevailed over the Island during most of December, when monsoon showers were experienced in the north and east with afternoon and evening thundershowers among the central hills and in the south-west. There were two spells of dry weather during the month, caused by dry north-easterly winds, one lasting from 20th to 22nd and the other from the 28th till the end of the month. The greater monthly totals of rainfall were found on the north-eastern slopes of, the central hills, and were of the order of 30 to 40 inches, the lowest totals were found in the north, north-west

and south-east of the Island, where some stations recorded amounts below 2 inches. The larger excesses of rainfall occurred to the east of the central hills, the largest of them being 20.83 inches at Ekiriyankumbura. Over most other parts of the Island, rainfall was below normal. The biggest deficit was 10.76 inches .at Blackwood Estate There were about 25 daily falls over 5 inches, the highest being 8.71 inches at Rufuskulam on the 26th.

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Meteorological Report for the Quarter October to December, 1958

	October								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	No. of Days	Offset
Anuradhapura ..	89·5	+0·6	74·5	+1·0	71	93	7·12	12	—2·60
Badulla ..	83·2	+0·4	66·5	+1·0	72	95	5·12	19	—3·77
Batticaloa ..	87·2	+0·2	76·4	+1·1	79	91	5·83	16	—1·36
Colombo ..	84·4	—0·4	76·8	+2·0	77	84	13·96	20	+0·25
Diyatalawa ..	76·2	—0·1	61·5	+1·0	78	92	9·78	20	+0·60
Galle ..	82·0	—0·9	+76·1	+0·7	81	86	14·66	26	+2·61
M'Illuppallama ..	88·7	+0·6	73·8	+0·5	71	90	7·39	15	—2·07
Hambantota ..	86·0	—0·2	76·8	+1·5	78	88	2·48	6	—2·28
Jaffna ..	84·9	—0·8	78·5	+0·9	81	86	9·17	11	— 0·3
Kandy ..	81·2	—4·	69·2	+1·3	78	92	11·11	22	—0·50
Kankesanturai ..	87·2	+0·3	77·4	+0·3	77	89	9·40	12	—0·22
Kurunegala ..	85·9	—1·2	74·2	+1·0	78	93	18·57	22	+3·71
Mannar ..	85·9	—0·9	78·1	+0·7	79	86	9·06	11	+2·48
Nuwara Eliya ..	66·4	—1·2	54·4	+2·2	84	88	12·50	24	+2·74
Puttalam ..	87·6	+1·3	77·4	+1·8	71	84	8·39	14	+0·96
Ratmalana ..	85·7	+0·6	76·8	+1·9	80	91	15·58	20	+2·38
Ratnapura ..	86·2	—0·9	73·7	+0·9	72	86	23·20	26	+5·19
Talawakele ..	69·6	—3·5	59·6	+1·8	88	94	13·62	24	+3·56
Tirncomalee ..	88·4	+0·4	76·1	+0·5	73	84	15·18	23	+5·63

	November								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	No. of Days	Offset
Anuradhapura ..	86·5	+0·7	72·3	+09·	81	95	7·76	20	—2·91
Badulla ..	81·2	+1·9	65·9	+0·5	75	92	7·72	19	—2·53
Batticaloa ..	85·5	+1·3	75·0	+0·8	80	93	11·98	17	—1·88
Colombo ..	85·2	0	73·8	+0·5	75	88	10·62	24	—2·47
Diyatalawa ..	75·7	+1·4	58·8	—1·0	79	85	11·95	20	+1·53
Galle ..	83·5	—0·1	74·8	+0·6	77	86	8·03	24	—3·98
M'Illuppallama ..	86·2	—	70·9	—	79	95	7·45	19	—
Hambantota ..	85·6	+02·	75·2	+1·2	76	88	2·99	12	—4·58
Jaffna ..	84·8	+0·7	76·3	+1·5	79	91	15·64	17	—1·63
Kandy ..	83·4	+05·	67·8	+0·4	78	95	10·05	21	—0·65
Rankesanturai ..	85·2	+1·0	76·1	+0·7	79	93	19·07	15	—1·93
Kurunegala ..	87·8	+0·9	72·4	+0·6	76	98	6·97	22	—5·42
Mannar ..	85·5	+0·9	77·3	+1·6	77	86	6·38	14	—3·81
Nuwara Eliya ..	69·0	+1·2	52·0	+0·9	77	84	8·21	14	—0·98
Puttalam ..	86·2	+0·5	74·3	+1·2	77	90	9·19	20	—0·94
Ratmalana ..	86·2	—0·2	73·3	+0·4	79	95	14·89	25	+2·77
Ratnapura ..	88·6	+0·8	72·2	0	74	90	14·45	20	—0·34
Talawakele ..	72·4	—	67·3	—	78	91	7·15	17	—
Trincomalee ..	85·2	+1·6	75·7	+0·9	76	86	10·37	23	—3·57

	December								
	Temperature				Humidity		Rainfall		
	Mean Maximum	Offset	Mean Minimum	Offset	Day	Night (from Min. Temps.)	Total	No. of Days	Offset
Anuradhapura ..	84·8	+1·5	70·6	+0·6	76	95	3·35	9	—4·17
Badulla ..	76·3	—0·3	65·2	+0·7	83	95	7·67	22	—3·56
Batticaloa ..	82·6	+0·7	74·5	+0·9	80	90	17·14	20	+0·15
Colombo ..	87·7	+2·2	72·8	+0·5	65	83	6·43	7	+0·82
Diyatalawa ..	71·8	—0·2	59·6	+1·0	85	94	4·95	20	—3·12
Galle ..	84·1	+0·6	74·0	+0·7	74	86	5·79	23	—2·03
M'Illuppallama ..	84·9	+1·5	69·2	—0·4	74	95	3·41	10	—4·65
Hambantota ..	86·4	+1·7	74·6	+1·5	70	84	1·61	6	—4·00
Jaffna ..	84·3	+1·8	74·0	+1·0	71	88	1·27	14	—9·12
Kandy ..	82·9	+1·1	66·9	+1·1	74	92	6·04	15	—2·83
Kankesanturai ..	84·4	+1·7	76·4	+1·5	72	79	2·19	13	—7·55
Kurunegala ..	86·6	+0·9	70·9	+0·2	69	93	3·65	6	—3·13
Mannar ..	84·6	+1·7	76·1	+1·2	72	84	2·83	9	—4·96
Nuwara Eliya ..	70·2	+2·5	50·9	+1·9	77	87	4·14	14	—3·67
Puttalam ..	86·8	+2·0	71·5	+0·3	69	90	3·57	10	—1·98
Ratmalana ..	88·3	+1·9	72·2	+0·5	71	93	6·69	10	+0·04
Ratnapura ..	89·5	+1·4	72·5	+0·9	77	95	5·54	19	—3·58
Talawakele ..	—	—	—	—	—	—	—	—	—
Trincomalee ..	82·4	+1·3	77·2	+2·3	73	76	10·75	16	—2·25

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